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AFML-TR-77-83

TEMPERATURE CONTROLLED QUARTZ CRYSTAL MICROBALANCE SYSTEM

FARADAY LABORATORIES INC.
LA JOLLA, CALIFORNIA 92037

MAY 3, 1977

TECHNICAL REPORT AFML-TR-77-83
Final Report for Period June 2, 1975 to May 3, 1977

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This technical report has been reviewed and is approved for publication.

R. A. Winn

R. A. WINN
Project Monitor

FOR THE DIRECTOR

J. K. Sieron

J. K. SIERON, Chief
Elastomers and Coatings Branch
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1.56 to the 9th power

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The TQCM system is designed to measure surface contamination as a function of temperature on the SCATHA satellite. The TQCM system consists of two radiatively-cooled Heads and a Controller. Each Head contains a removable high-sensitivity (1.56×10^{-9} g/cm^2) mass sensor, temperature probe and heater. By ground command, the Controller can set both sensors to operate simultaneously at +100, +30, 0, -30, -60°C ±1°C or free run. Computer thermal modeling shows that a free running Head pointed into deep space will reach an equilibrium temperature of -163°C.

sq cm

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PREFACE

This report was prepared by D. McKeown, C.R. Claysmith W.T. Breckenridge, Jr. and R.S. Dummer of Faraday Laboratories Inc., La Jolla, CA 92038, under Contract F33615-75-C-5171. This program was initiated under IL1R0071, Laboratory Director's Funds. The program was administered under the direction of the Elastomers and Coatings Branch (MBE), Nonmetallic Materials Division, Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio, with Mr. Robert A. Winn serving as project engineer.

This report covers research and development conducted during the period of June 1975 to December 1976.

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SUMMARY

The Final Report describes the design and construction of a Temperature-Controlled Quartz Crystal Microbalance (TQCM) system for flight on the SCATHA satellite. The TQCM system consists of two radiatively-cooled Heads and a Controller. Each Head contains a removable high-sensitivity mass sensor, temperature probe and heater. By ground command, the Controller can set both sensors to operate simultaneously at +100, +30, 0, −30, −60°C ±1 C° or free run. For free run, a Head reaches an equilibrium temperature depending on its view of space. For example, results from a computer thermal model show a Head periodically viewing the sun and deep space will reach about −67°C while a Head continuously pointed into deep space will reach about −163°C.

TQCM inputs are temperature commands, power, enable and clock. Outputs for each Head are high and low-sensitivity mass and sensor temperature 0 to 5 volt analogs and frequency vs mass.

The mass sensors are instrumented with low-power dissipation 15-MHz, aluminum plated, optically-polished quartz crystals. Mass sensitivity is 1.56×10^{-9} g/cm^2-Hz which is over two times greater than 10-MHz crystals now being used in space.

Each Head is 5.7 x 5.7 x 3.9 in and weighs 1.4 lb.

The Controller is 4.8 x 5.6 x 3.3 in and weighs 1.8 lb.

The TQCM system operates on +28 ±4 Vdc at 2.142 W for heaters OFF and 5.07 W for heaters ON.

A structure is provided in each Head for mounting a potential analyzer to determine the effects of spacecraft charge on surface contamination.

1.0 Introduction

The TQCM system design is based on the Cryogenic QCM[1] (CQCM) constructed for flight on the NASA Shuttle. The CQCM is radiatively-cooled and operates at minimum temperatures to measure water vapor contamination.

The TQCM makes use of the CQCM thermal modeling, high-sensitivity, removable mass sensors and low-power dissipation electronics. The TQCM has the added capability of temperature control by command.

The TQCM design incorporates temperature commands because of the need to measure various species of contamination including water vapor as a function of temperature. The TQCM sensor temperature can be set by command to operate at +100, +30, 0, −30, −60°C ±1C or free run.

2.0 TQCM System

The TQCM system size and weight are shown in Figure 1. The enlarged view of the sensor shows location of the quartz crystals.

A photograph of the system is shown in Figure 2. The small tabs at the four corners of each mirror are for electrically grounding the radiator to the satellite. The square region in the center of the Head is for mounting a potential analyzer for studying surface contamination as a function of spacecraft charge.

Different views of the Head and Controller are shown in Figures 3, 4 and 5.

3.0 Thermal Analysis

The amount of power, W, radiated by a surface is defined by

$$W = \epsilon\sigma\,(T_1^{\,4} - T_0^{\,4})$$

where ϵ is surface emittance, σ the Stefan-Boltzman constant (5.67 x 10^{-9} W/m^2K^4) and T_1 and T_0 are respectively the surface temperature and the temperature of space in °K.

The power radiated by a surface (140°K) into space (4°K) is 2.18 mW/cm^2. For a 100 cm^2 radiator, suitable for cooling a TQCM, the

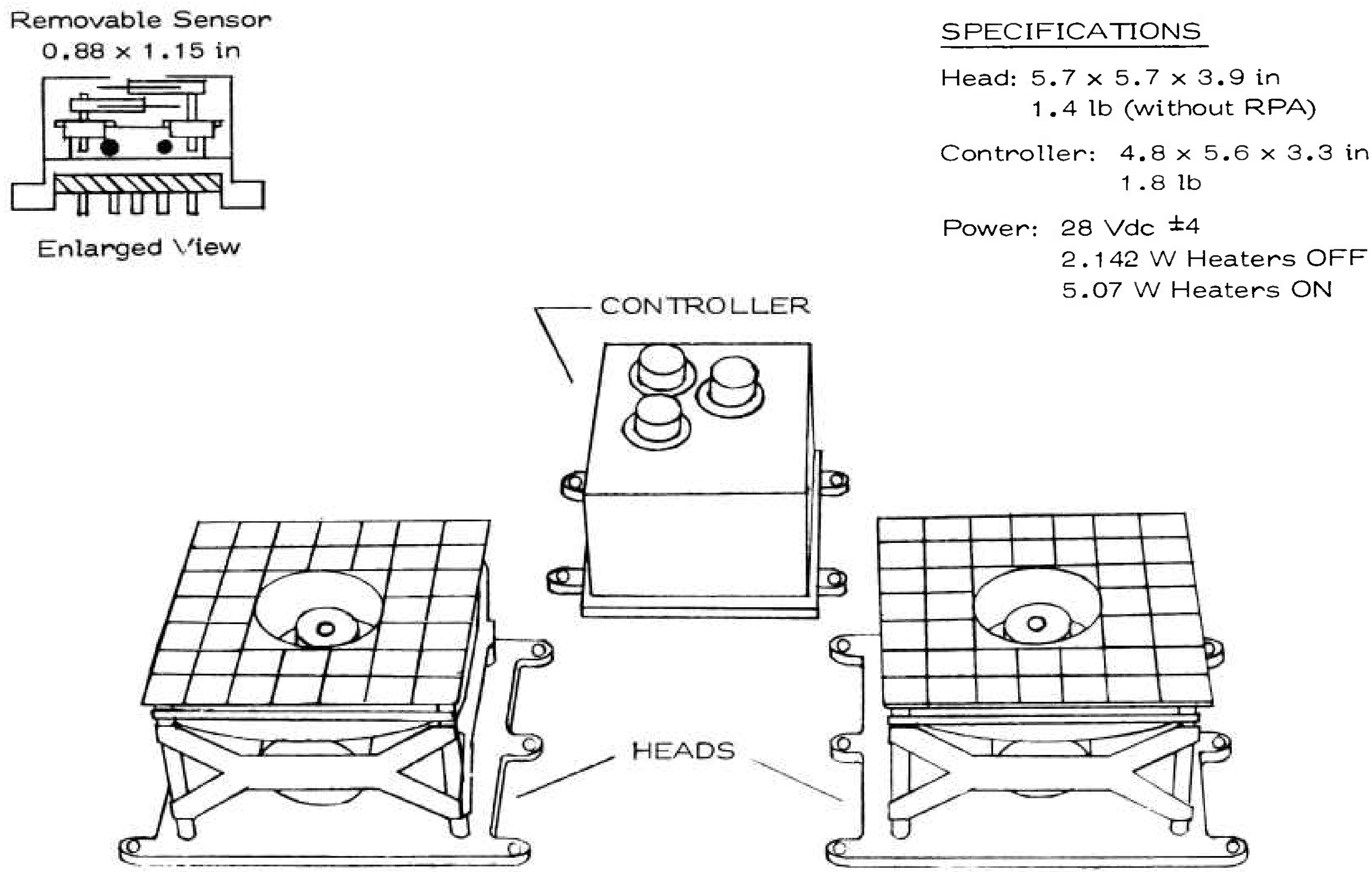


Figure 1 TQCM System Specifications

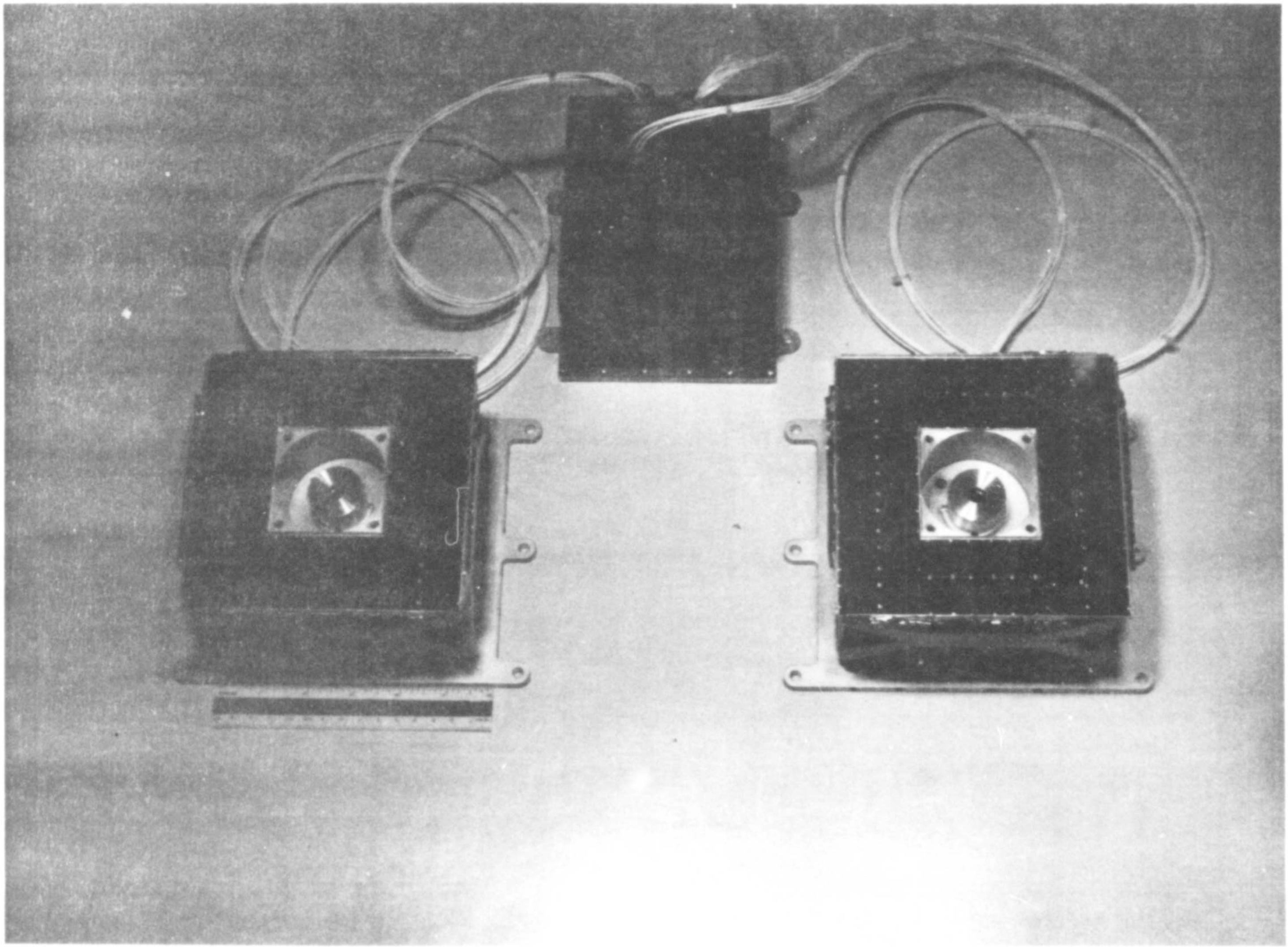


FIGURE 2 TQCM SYSTEM WITHOUT RPA INSTALLED

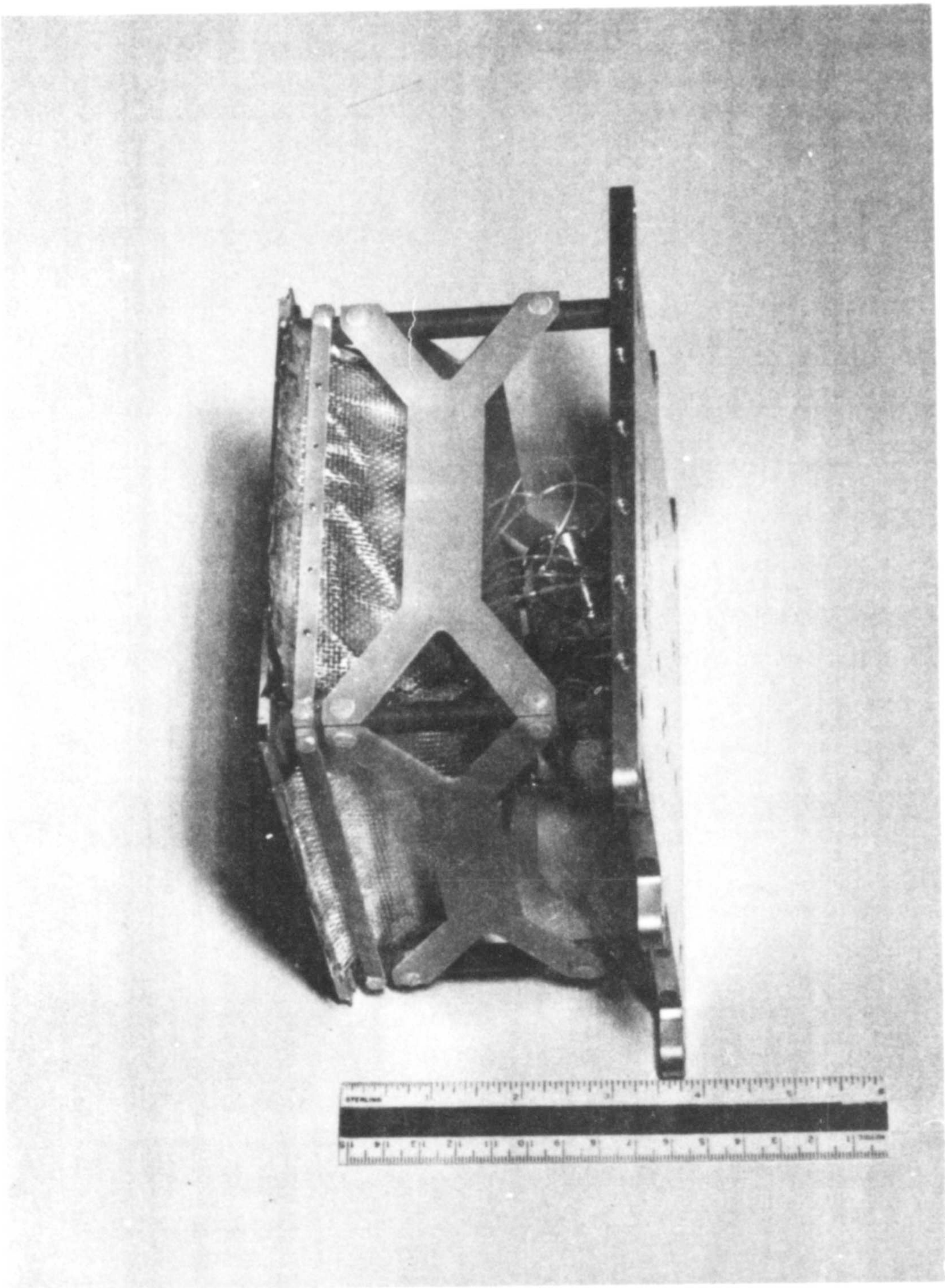


FIGURE 3 TQCM HEAD SHOWING ELECTRONICS AND SUPER INSULATION

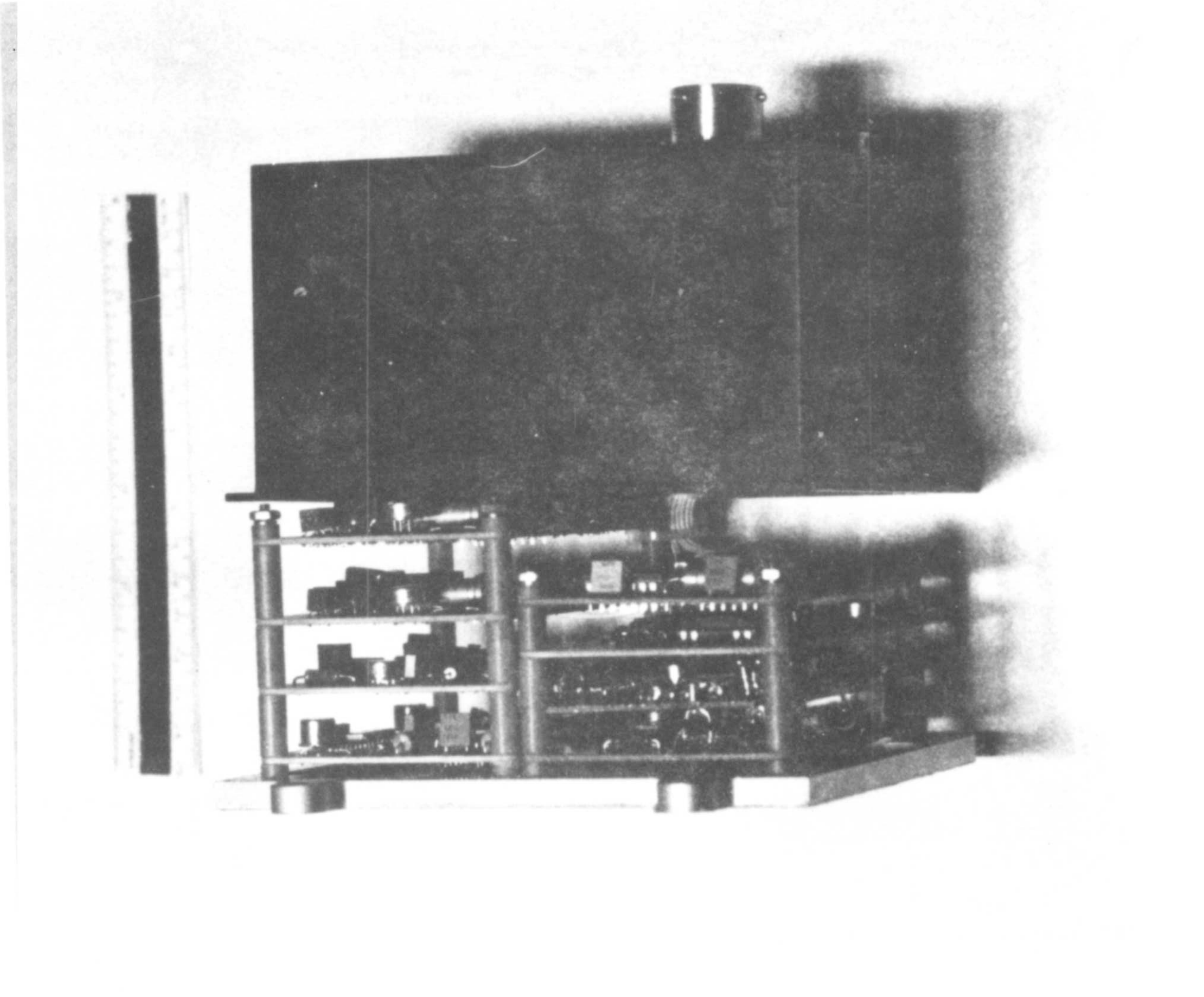


FIGURE 4 TQCM CONTROLLER SIDE VIEW

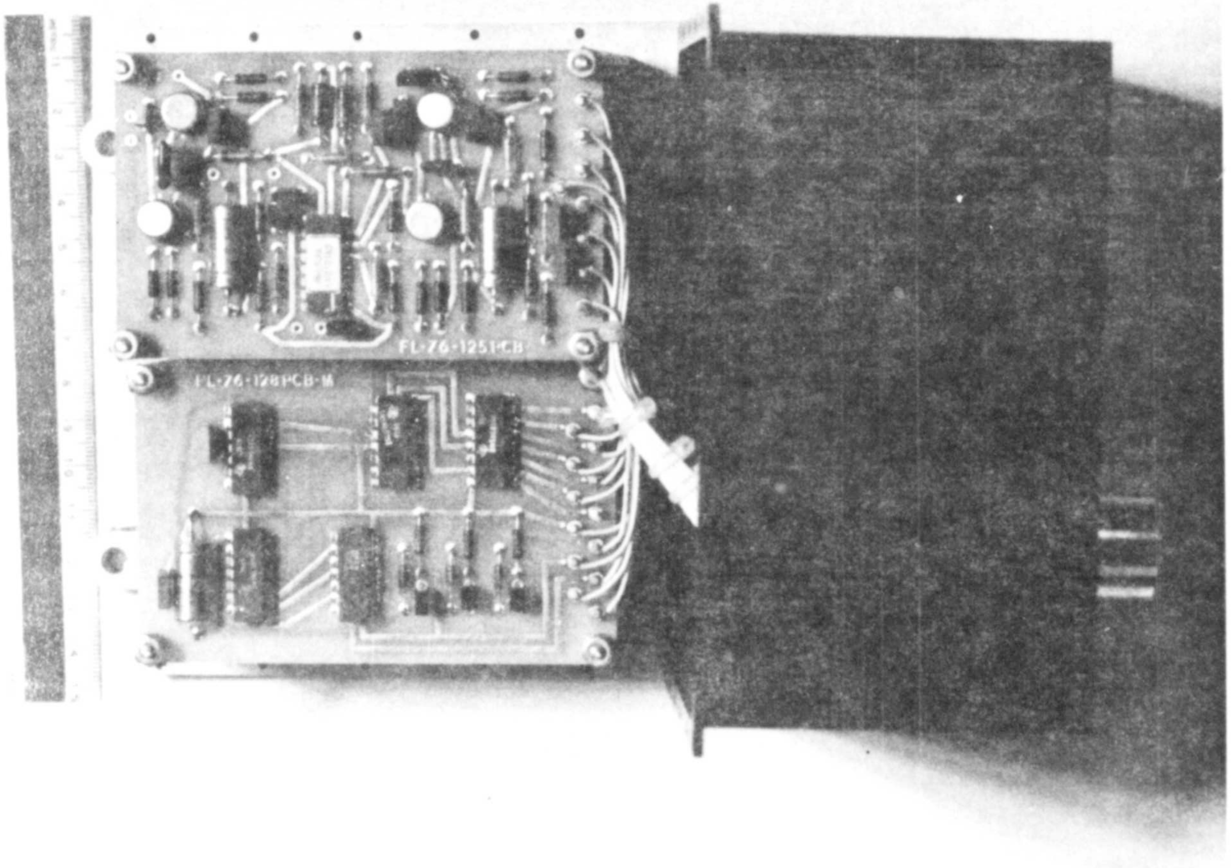


FIGURE 5 TQCM CONTROLLER SHOWING FREQ/VOLT CONVERTERS BOARD No. 125 AND SERIAL COMMAND DECODER BOARD No. 128

power is 213 mW. In practice, the effective cooling is much less because:

a) Surface emittance is less than unity
b) Backside of the radiator will absorb heat from the spacecraft
c) Conduction of heat from the spacecraft to the radiator
d) Oscillating quartz crystal sensor dissipate power

The optimum TQCM Head design was determined by computer modeling.[2] Several computer runs were made on Head designs using various materials for its construction and different levels of power dissipations in the crystal sensors.

The final Head design is shown in Figure 6. The Head contains the radiant cooler, mass sensors, oscillators and output amplifier. The radiant cooler is a plane surface constructed from aluminum. The sensors are mounted in a well machined in the radiator. Second-surface quartz silver plated mirrors are attached with RTV to the radiator.* The mirror front surfaces are coated with a conducting layer of indium oxide for grounding purposes. The mirrors have a solar absorptance $\alpha \approx 0.08$ and a thermal emittance $\epsilon \approx 0.80$. The radiator is attached to the base plate by four high-strength fiberglass-epoxy laminate standoffs. The electronic unit is connected to the crystal sensor by 0.005 in diameter Stablohm leads to provide thermal isolation.

Radiative heat exchange from spacecraft to the radiator is minimized using a stacked multilayer superinsulation of gold plated Kapton held in place beneath the radiator by a Teflon screen.

After the Head design was fixed, its operation in space was determined by computer analysis. Calculated minimum equilibrium temperatures are shown in Figure 7 for a Head viewing space and in Figure 8 for viewing the sun and space at 1 RPM.

The heating powers required to maintain the space oriented Head at various set temperatures are shown in Figures 9 - 13. The sensor operates at a higher temperature than the set temperature because of its power dissipation.

The heating powers required to maintain the 1 RPM sun oriented Head at various set temperatures are shown in Figures 14 - 18. The sensor operates above set temperature because of its power dissipation.

4.0 TQCM Electronics

The goal of the electronics design was to minimize power dissipation in the TQCM so as not to excessively load the radiant cooler.

* Mirror attachment was made by the Aerojet Electro Systems Co. through the assistance of Dr. M.K. Barsch.

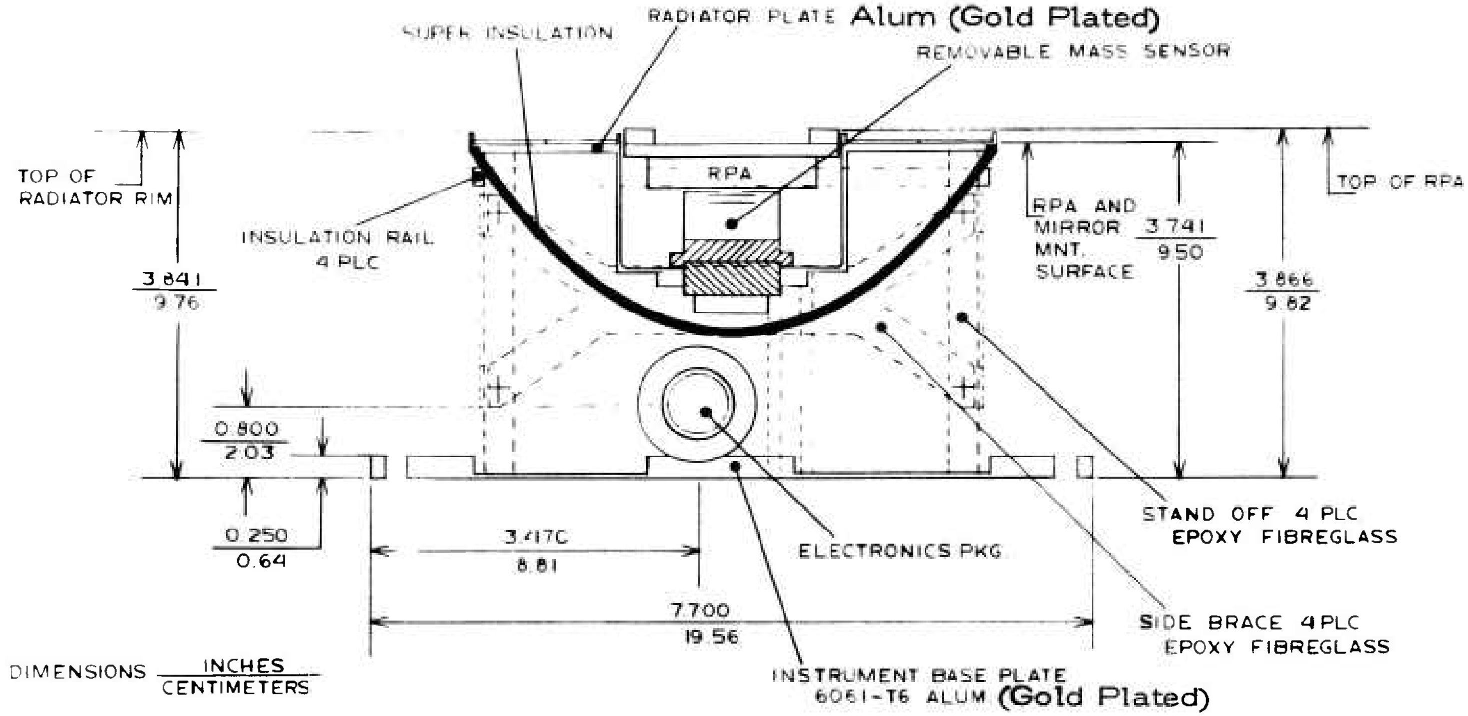


Figure 6 TQCM Head Design

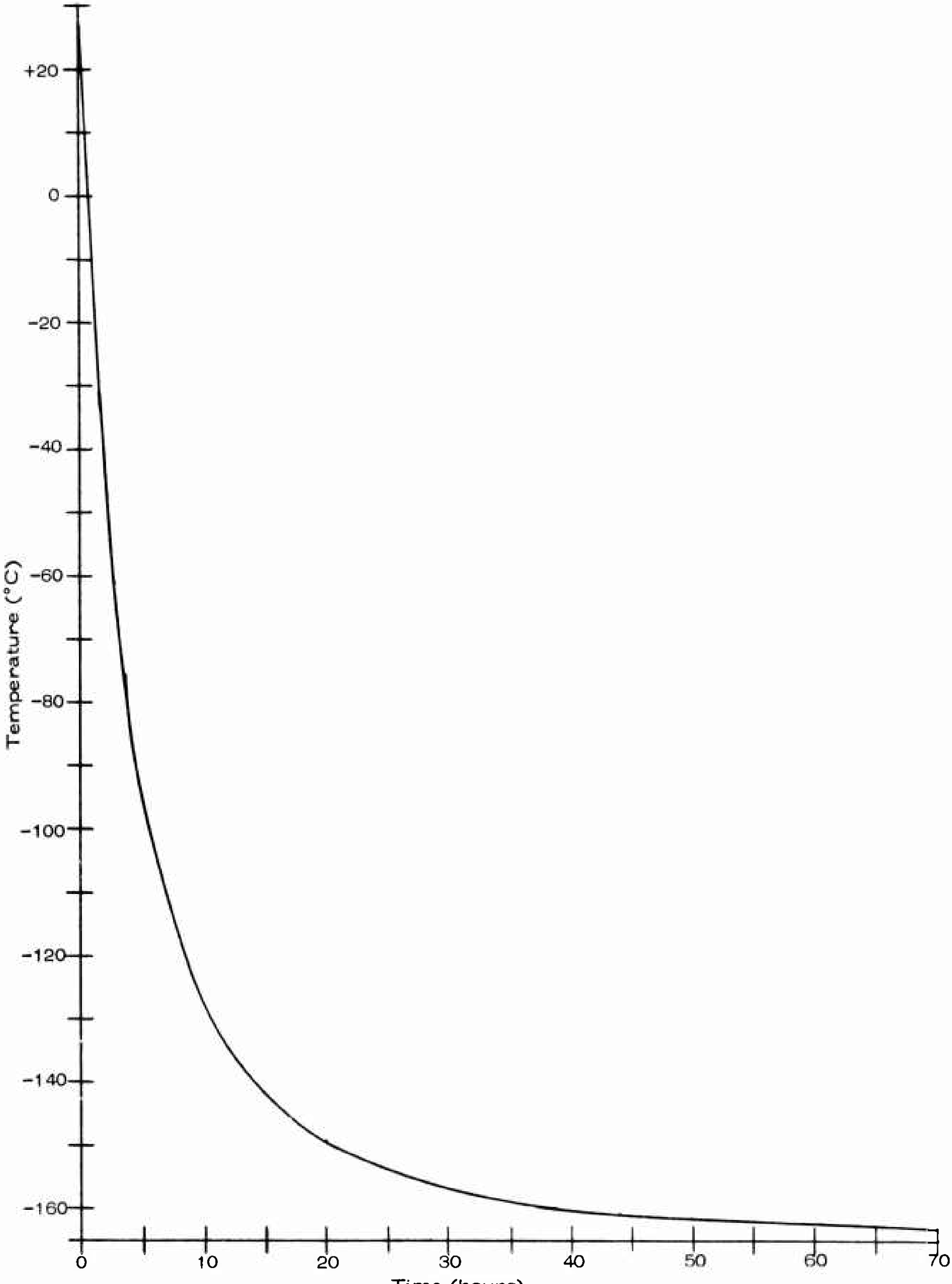


Figure 7 TQCM Sensor Crystal Cool-Down When Pointed into Deep Space

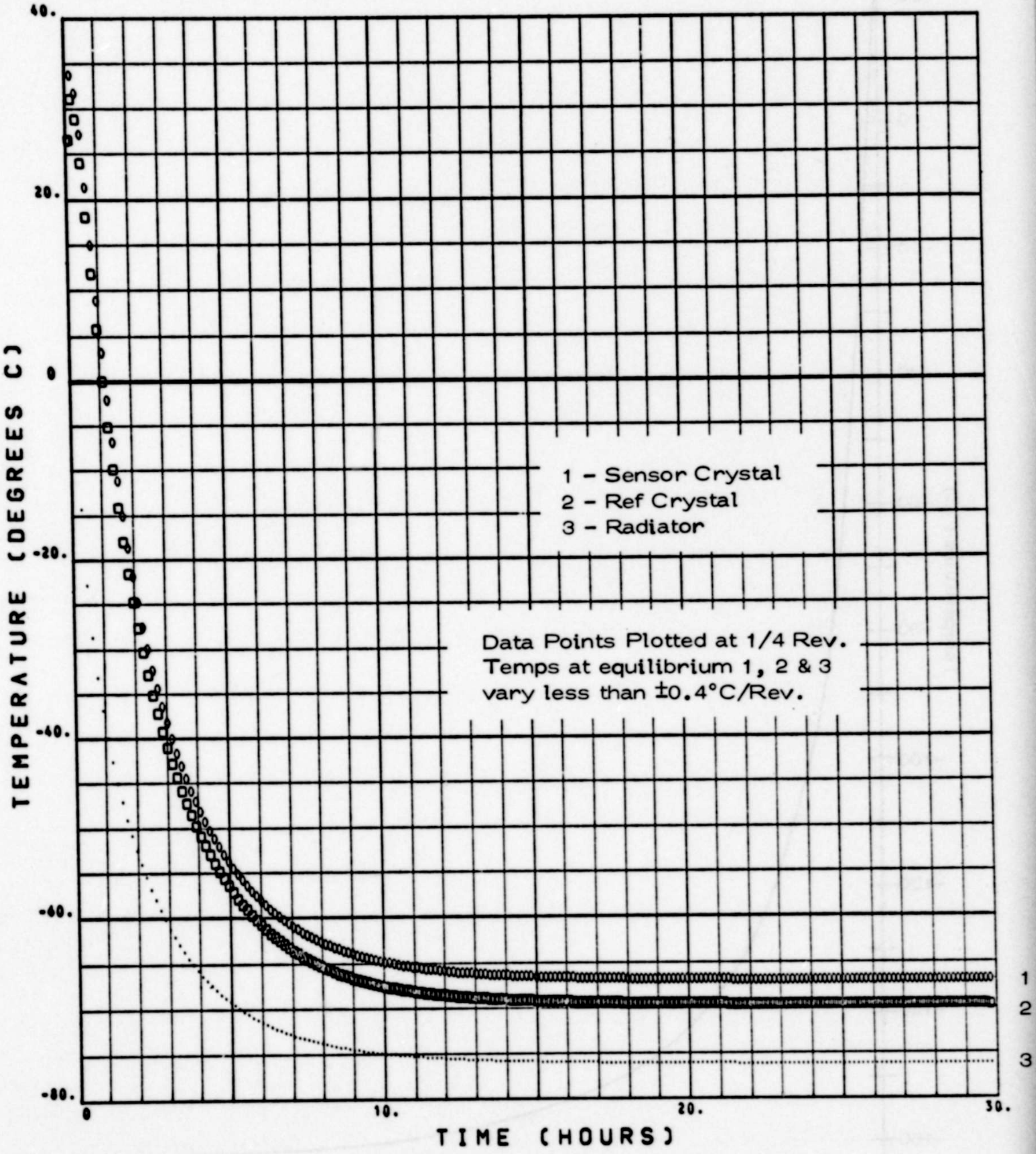


Figure 8 TQCM Cool-Down When Viewing Sun at 1 RPM

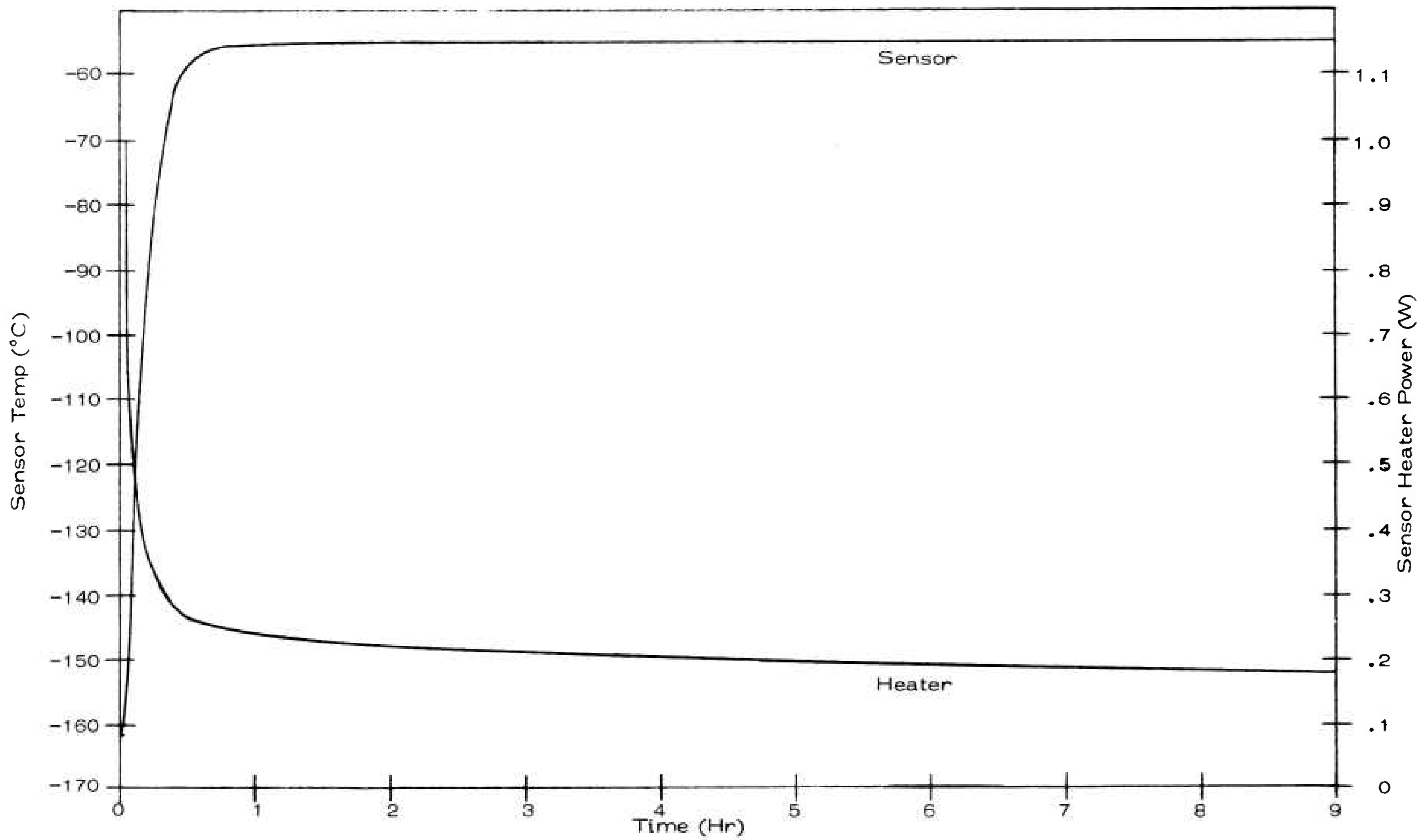


Figure 9 Sensor temperature and heater power for space oriented TQCM commanded to -60°C

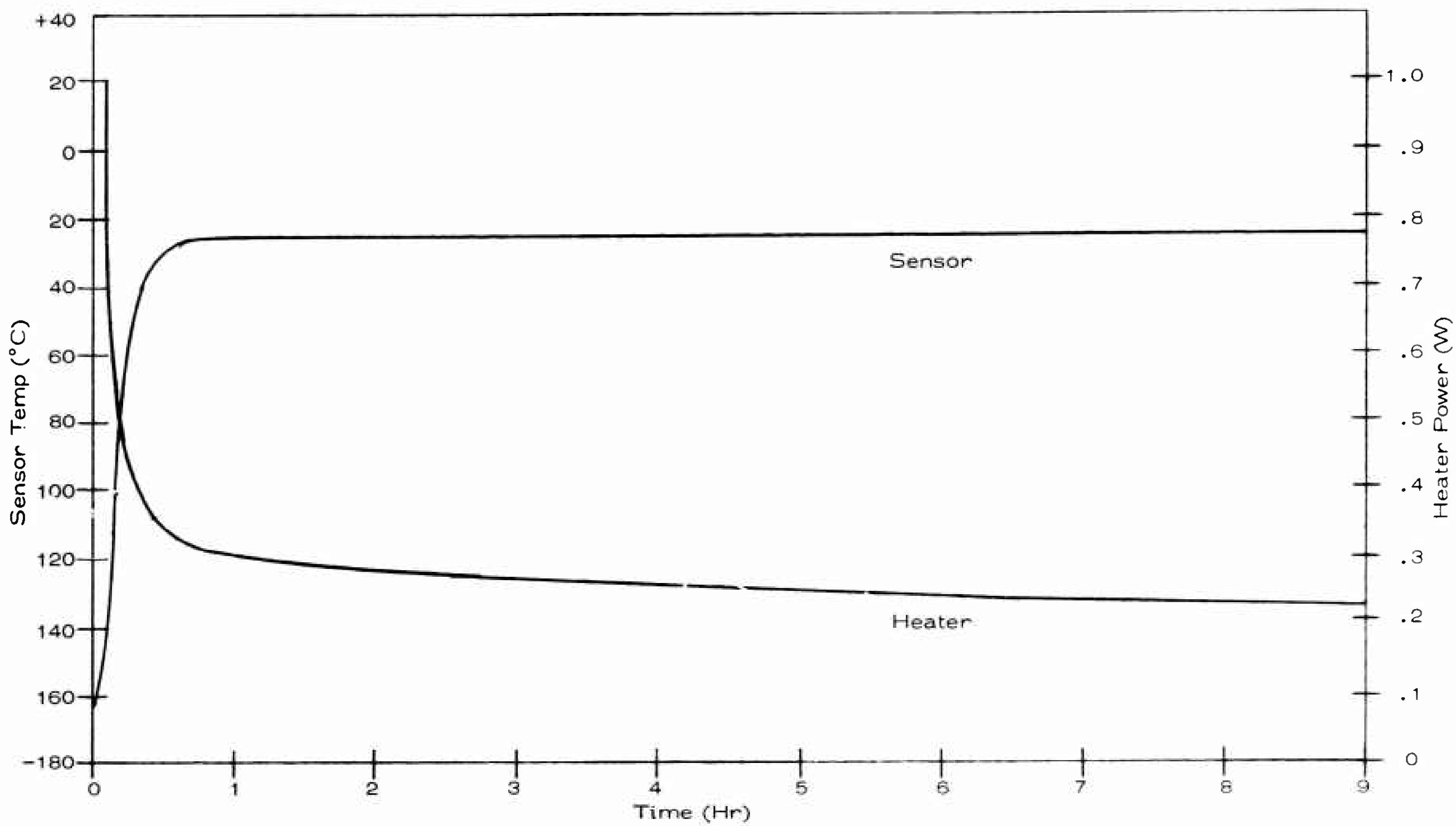


Figure 10 Sensor temperature and heater power for space oriented TQCM commanded to −30°C

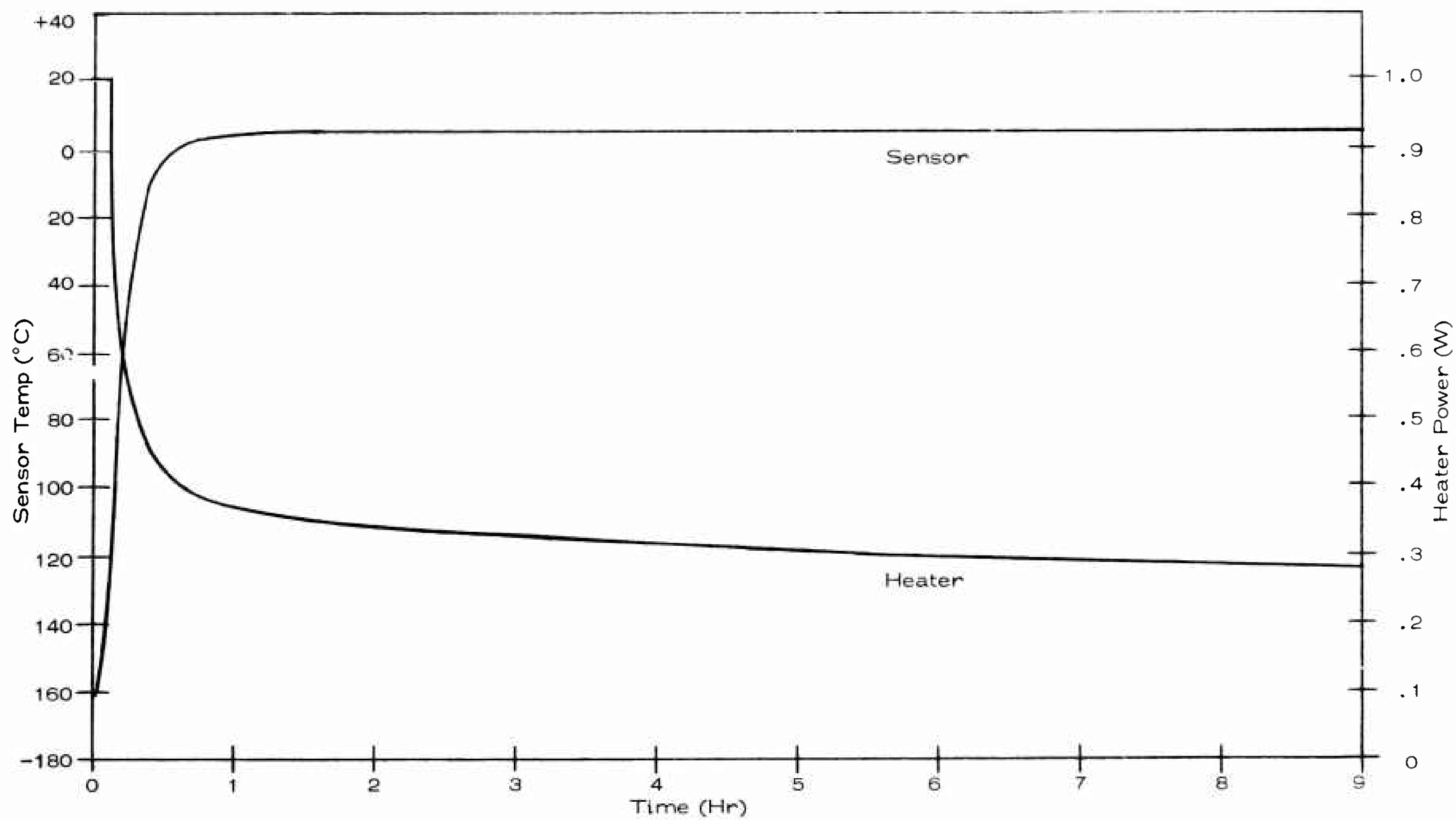


Figure 11 Sensor temperature and heater power for space oriented TQCM commanded to 0°C

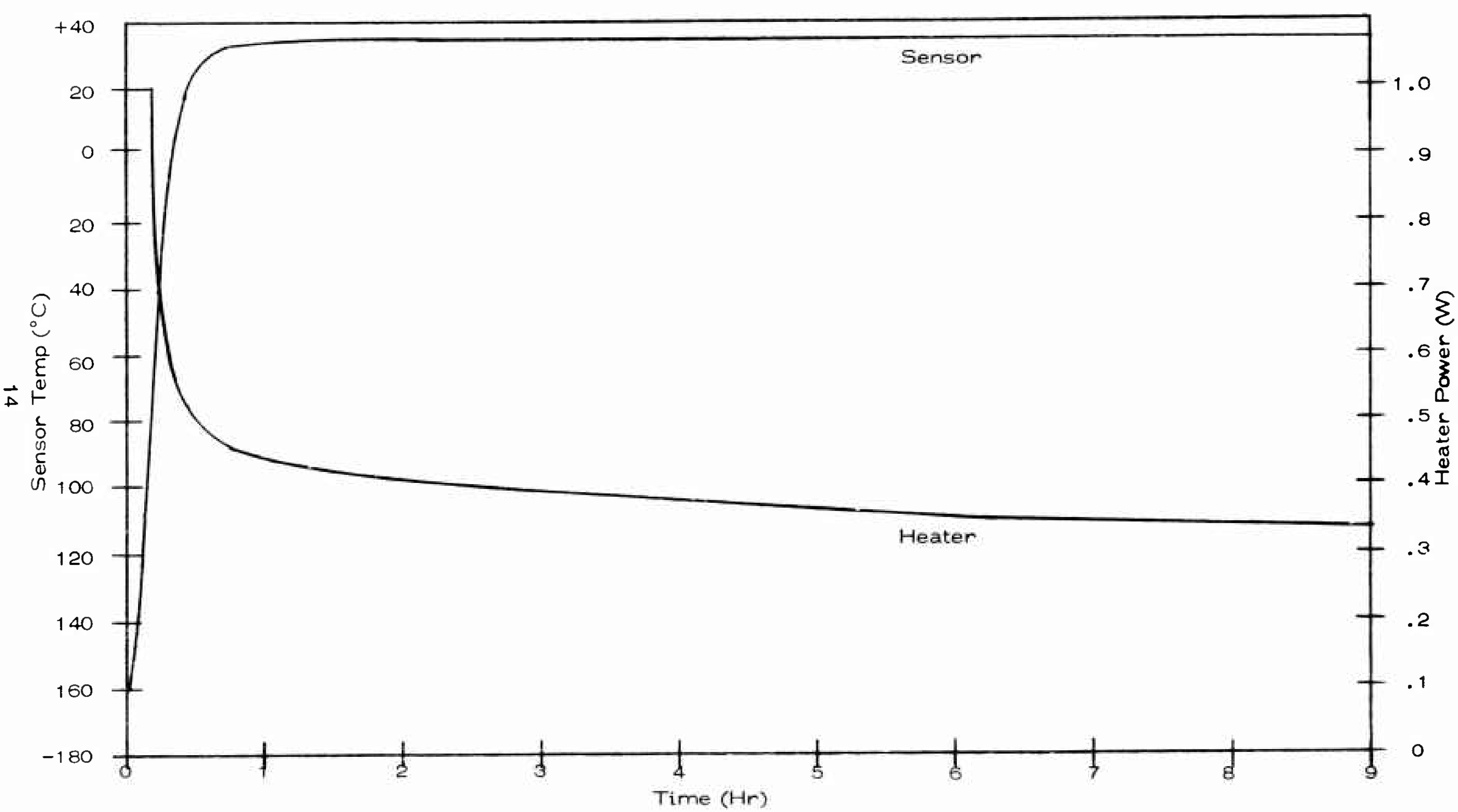


Figure 12 Sensor temperature and heater power for space oriented TQCM commanded to +30°C

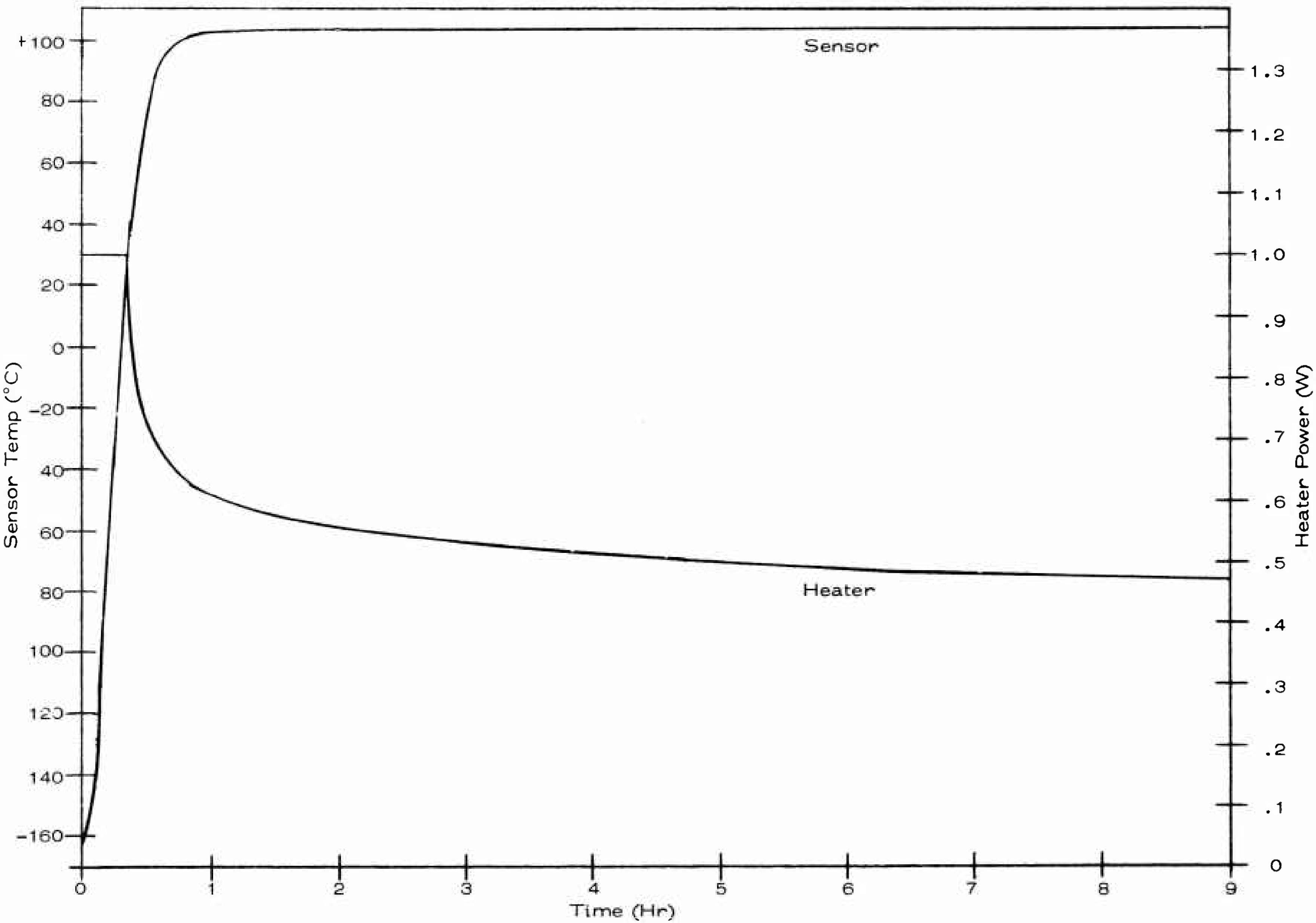


Figure 13 Sensor temperature and heater power for space oriented TQCM commanded to +100°C

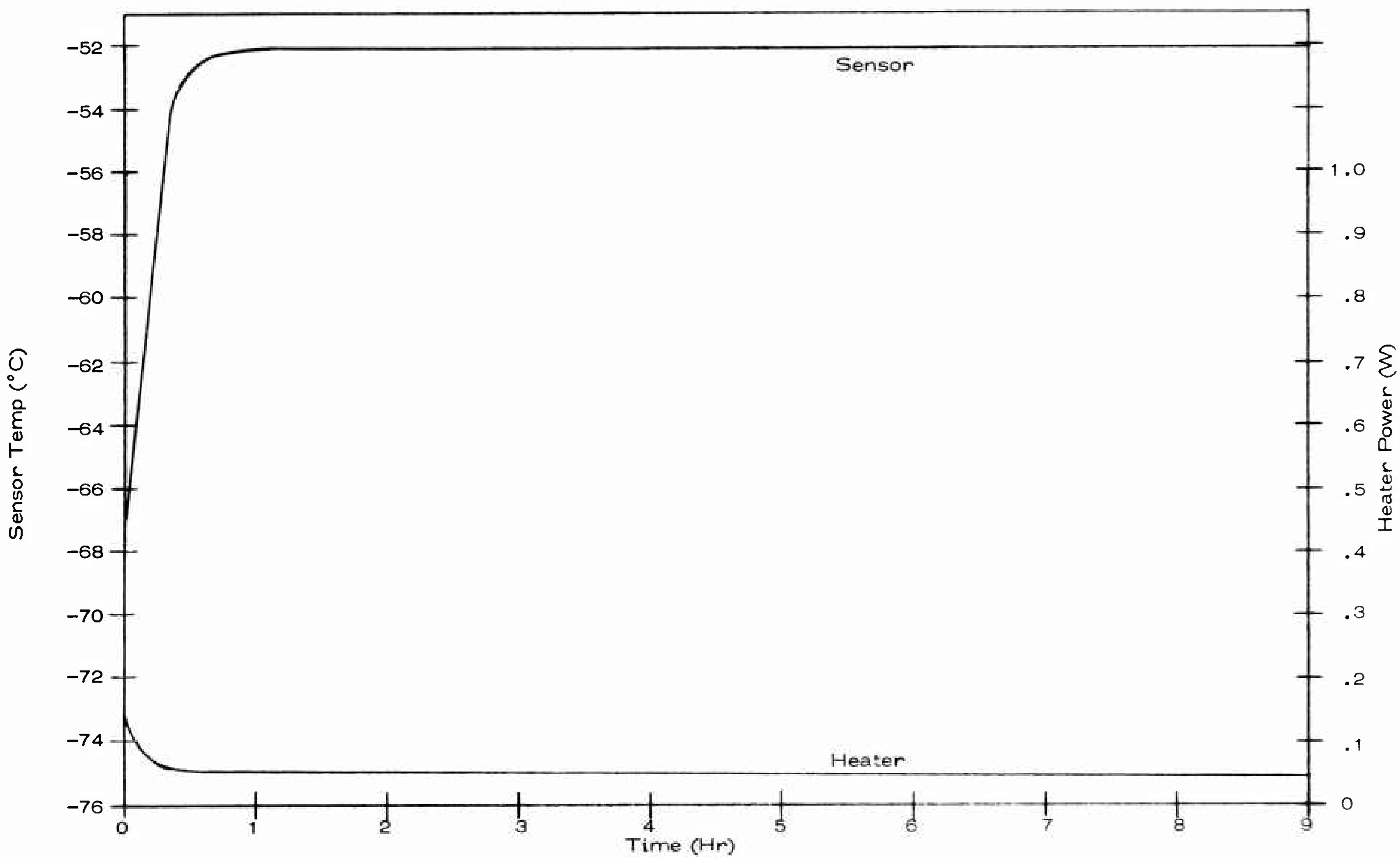


Figure 14 Sensor temperature and heater power for sun oriented TQCM commanded to −60°C

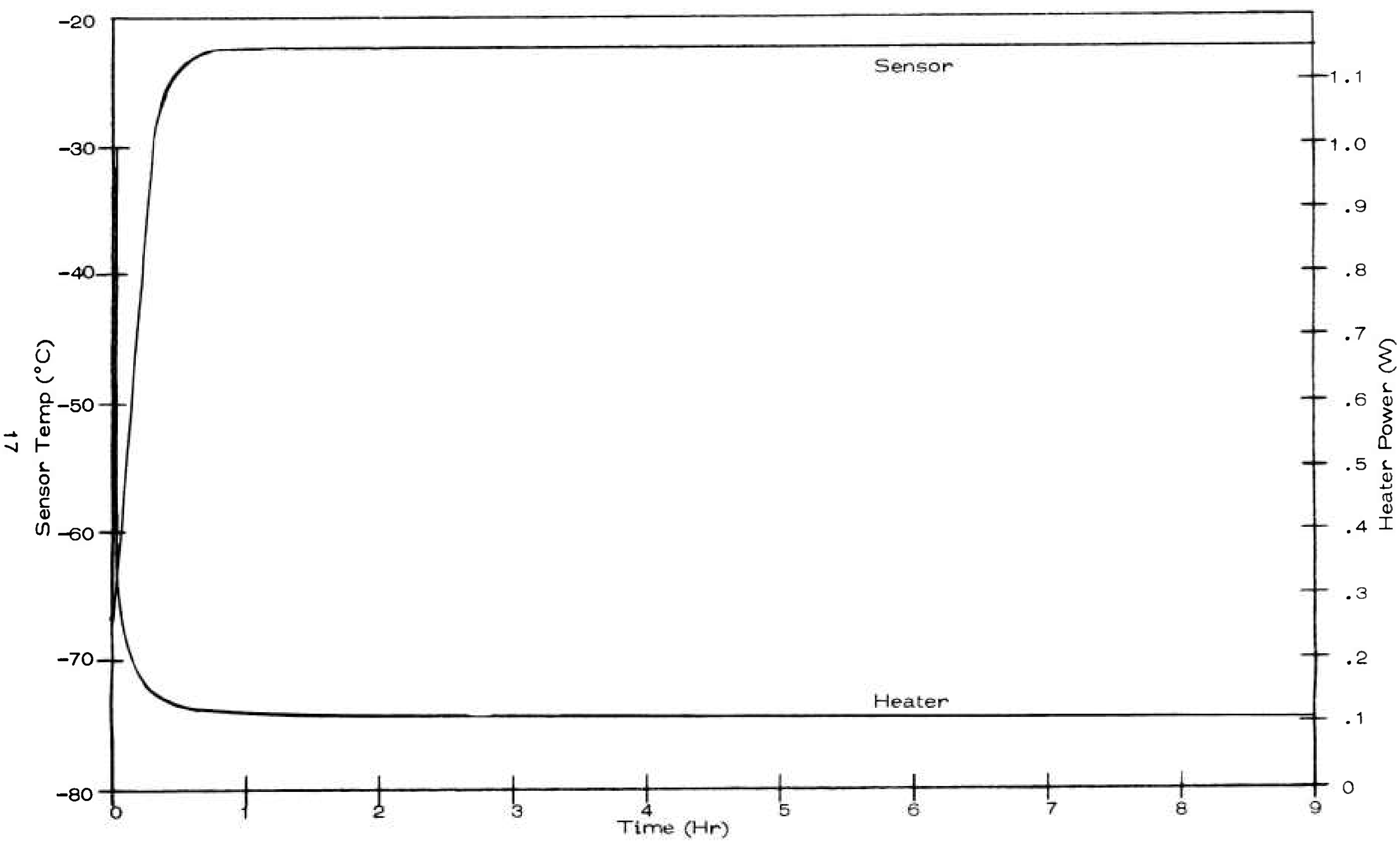


Figure 15 Sensor temperature and heater power for sun oriented TQCM commended to -30°C

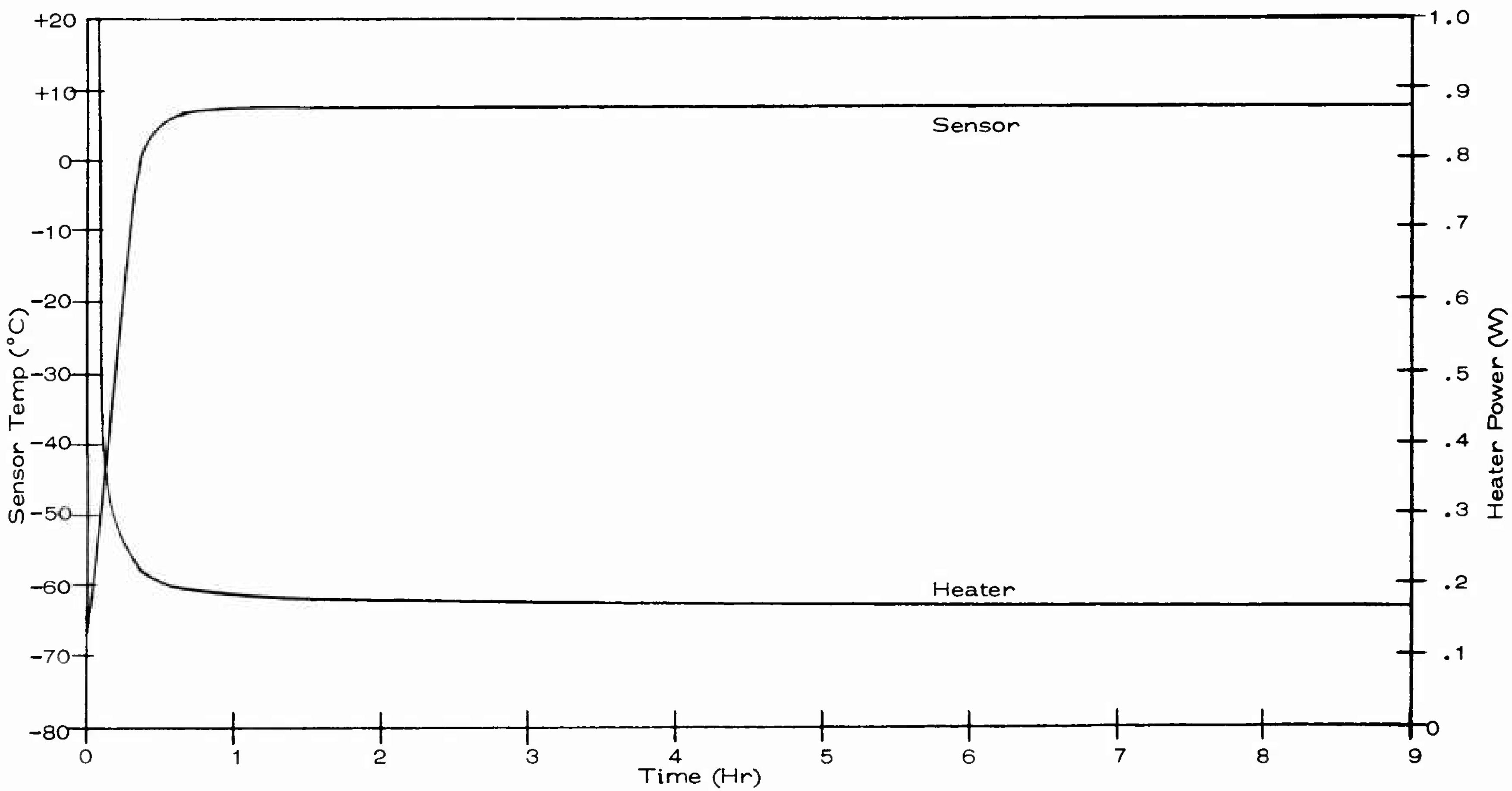


Figure 16 Sensor temperature and heater power for sun oriented TQCM commanded to 0°C

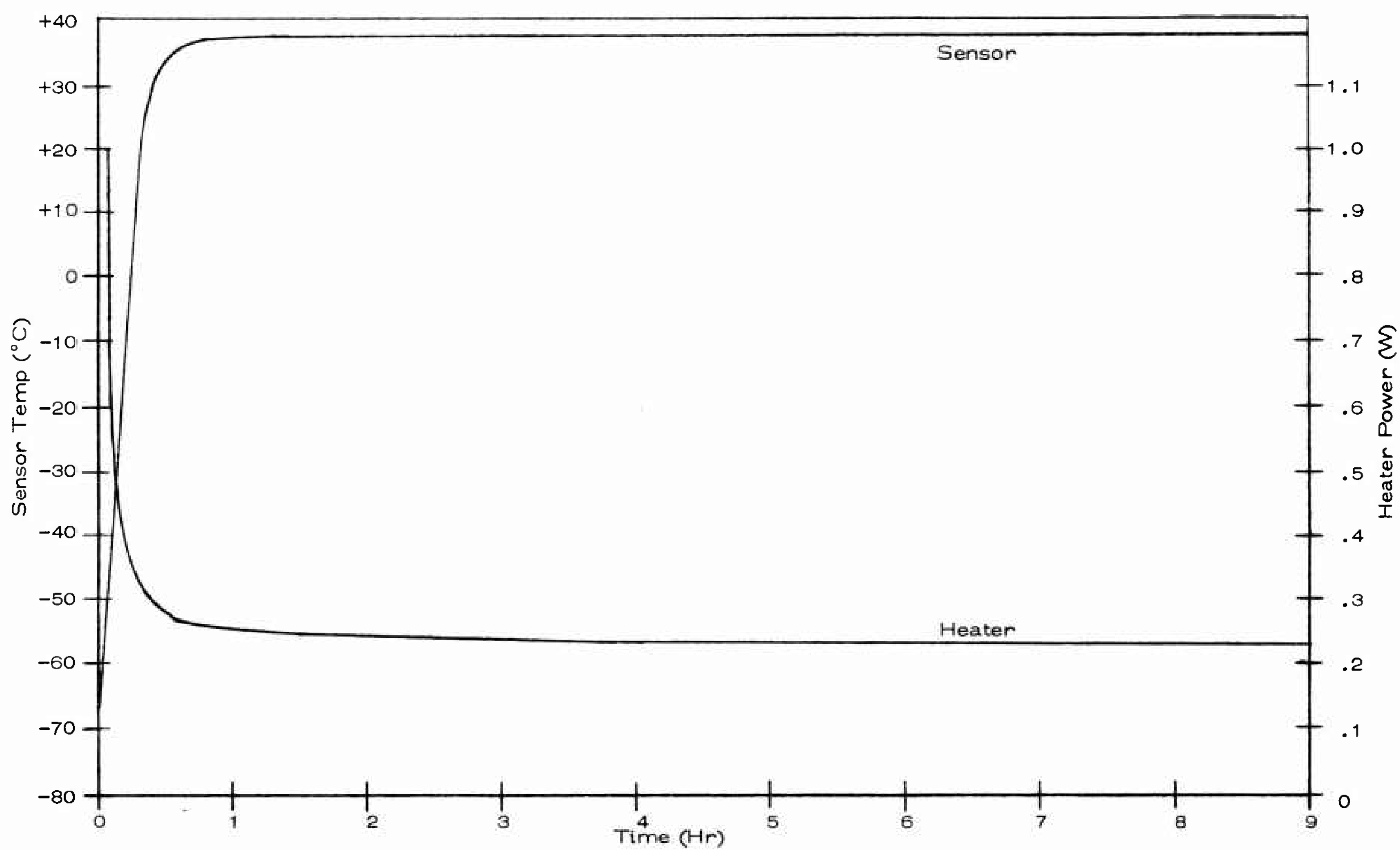


Figure 17 Sensor temperature and heater power for sun oriented TQCM commanded to +30°C

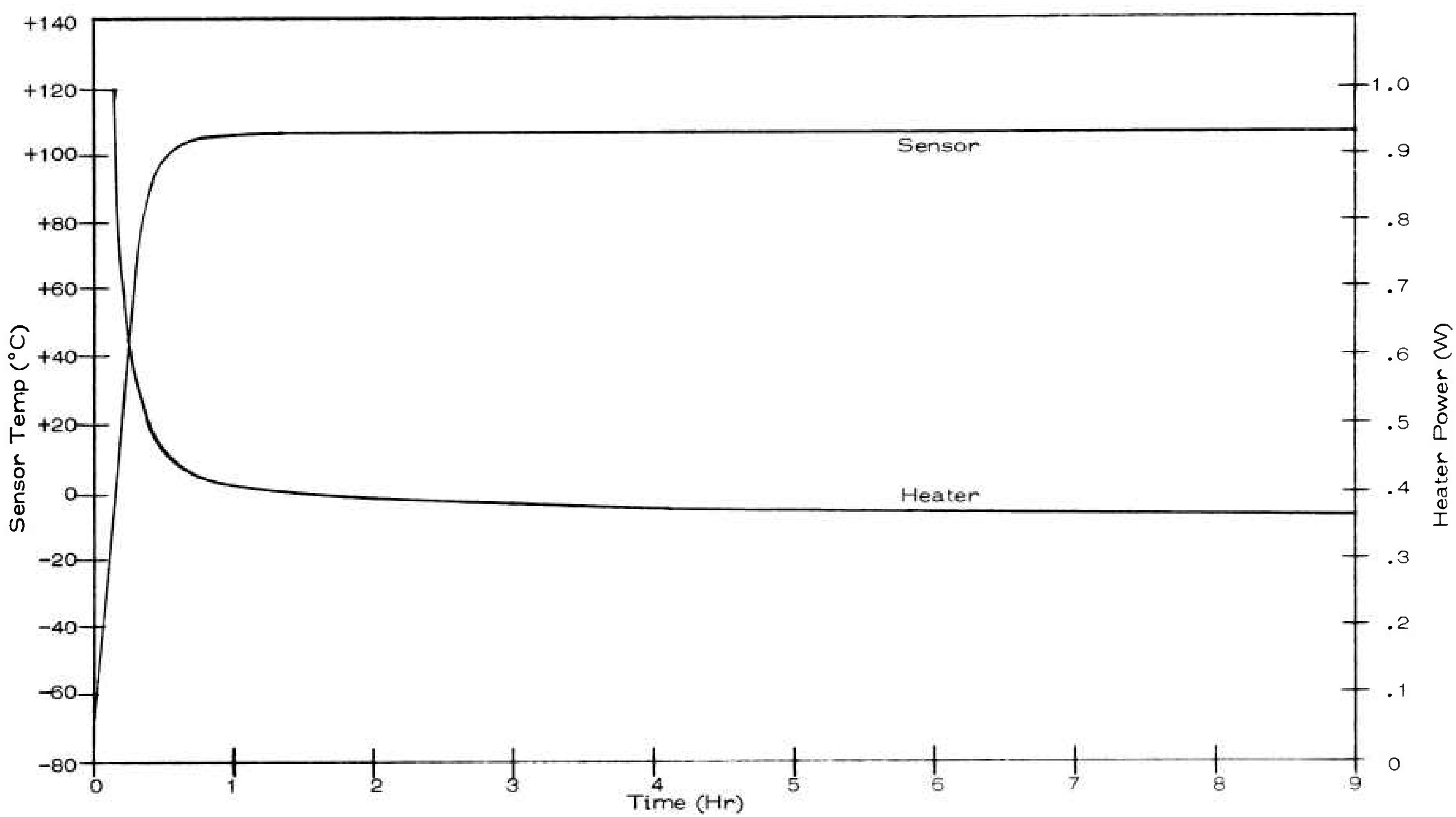


Figure 18 Sensor temperature and heater power for sun oriented TQCM commanded to +100°C

The TQCM system interconnections are shown in Figure 19.
The Head electronics block diagram is shown in Figure 20.
The Controller electronics block diagram is shown in Figure 21.

4.1 Oscillators

Oscillators are designed with a wide band width to operate 15-MHz crystal sets.* The power dissipation for the oscillators is 5 mW. The oscillator diagram is shown in Figure 22.

4.2 Beat Frequency

The oscillators drive a mixer-beat-frequency operational amplifier having a low impedance high-gain output. The total power dissipation of the TQCM oscillators and operational amplifier is only 16 mW and represents a reduction of better than 2/3 over the best QCM now available. The frequency output of the amplifier is proportional to sensor crystal contamination loading. This frequency is provided as an output for direct monitoring of contamination. The frequency is also fed into a converter to provide an analogue output for spacecraft telemetry. The mixer and output amplifier diagram is shown in Figure 23.

4.3 Frequency Converter

The analogue output of frequency is provided by a two frequency-analogue (F/A) converter. The high and low sensitivity converters are shown in Figure 24. Capacitor/resistor networks on the outputs protect the converters from damage by telemetry voltage surges.

4.4 Heater Driver

The sensor heater requires about 1 W during operation. The heater driver shown in Figure 25 provides this heavy power.

4.5 Temperature Bridge

The temperature of mass sensors is monitored by a precision helium-filled platinum thermometer linear to 0.5%. The bridge output

* Crystal set dissipates $< 100\ \mu W$ depending on drive level

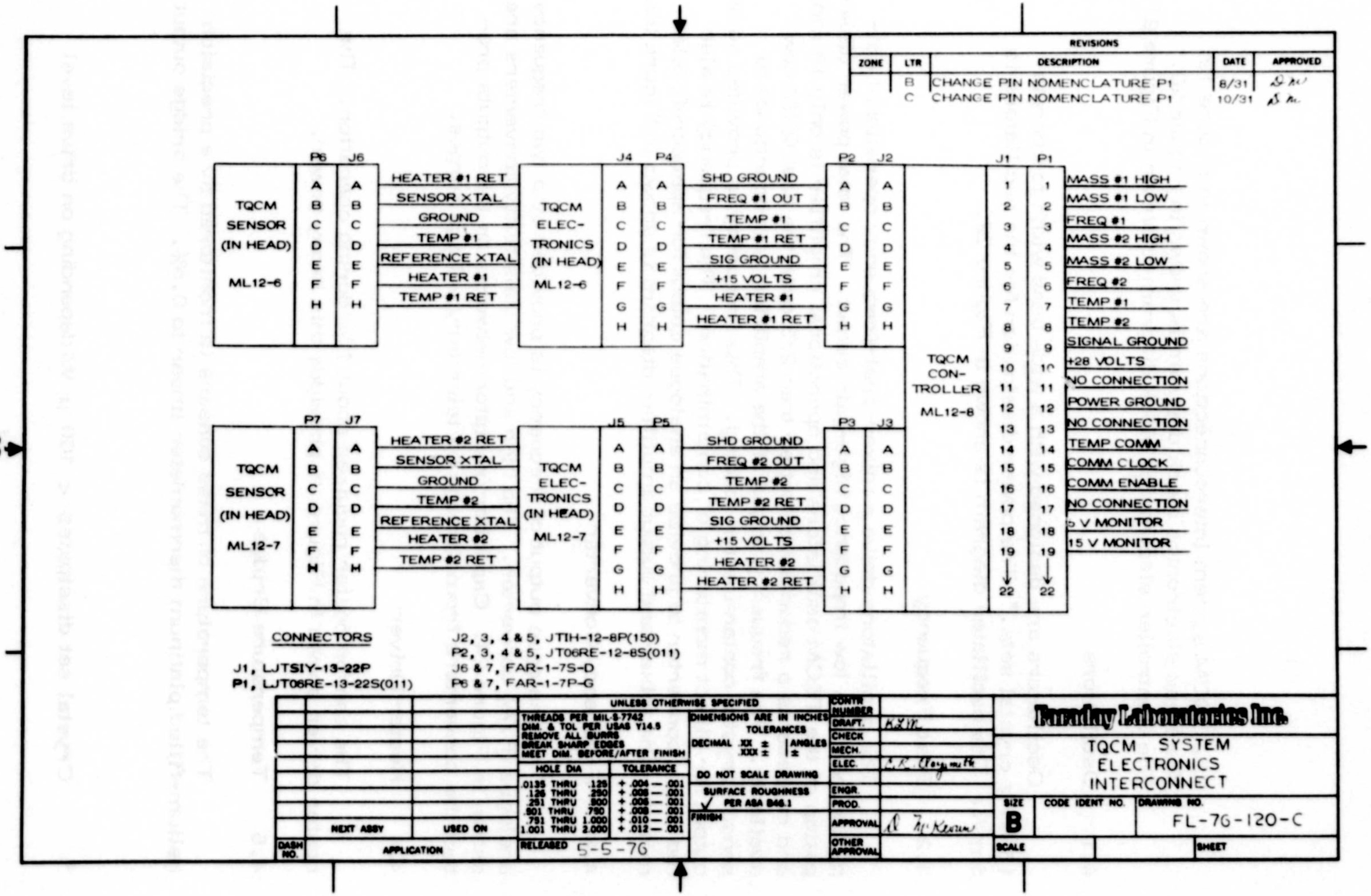
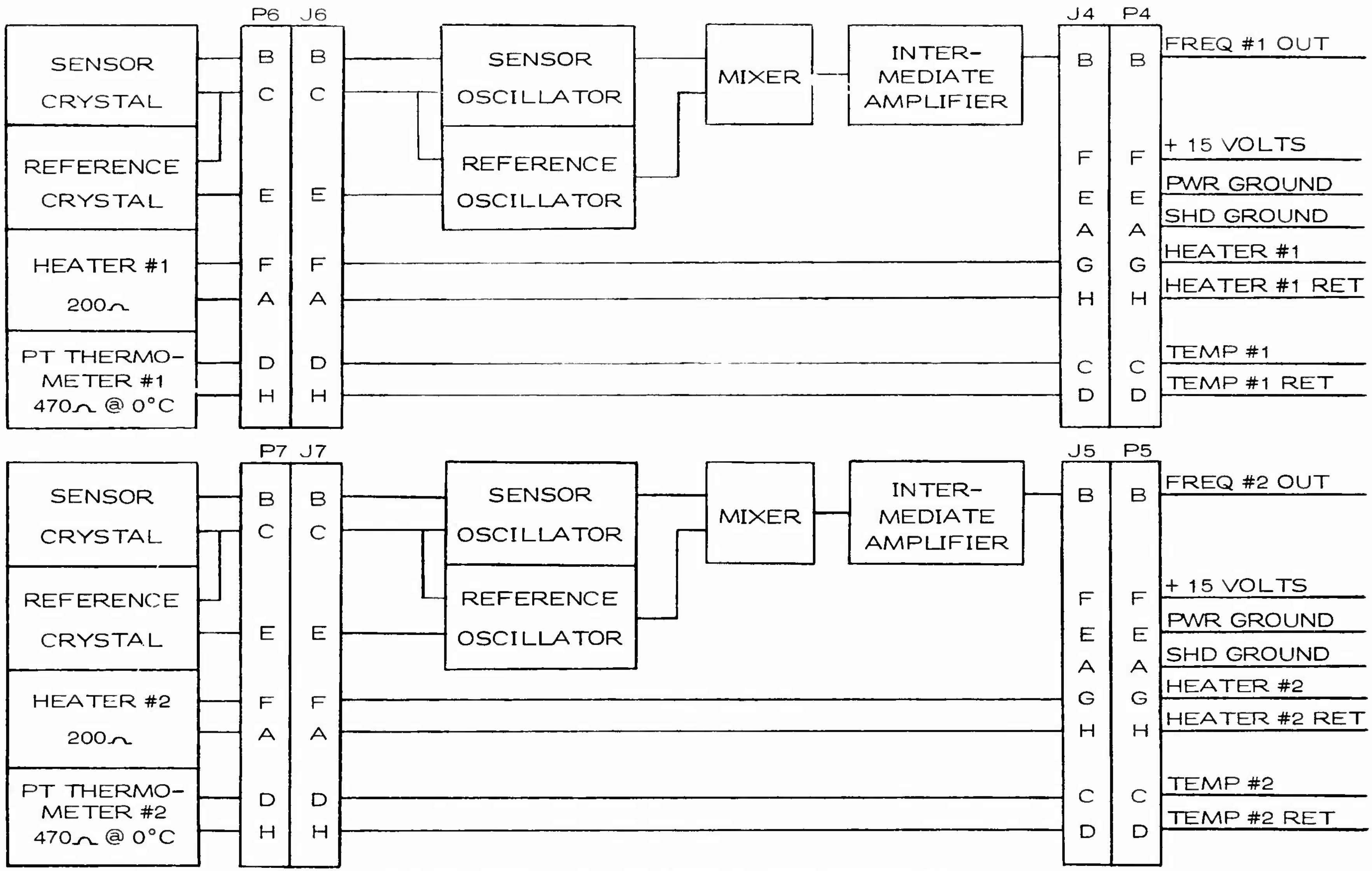
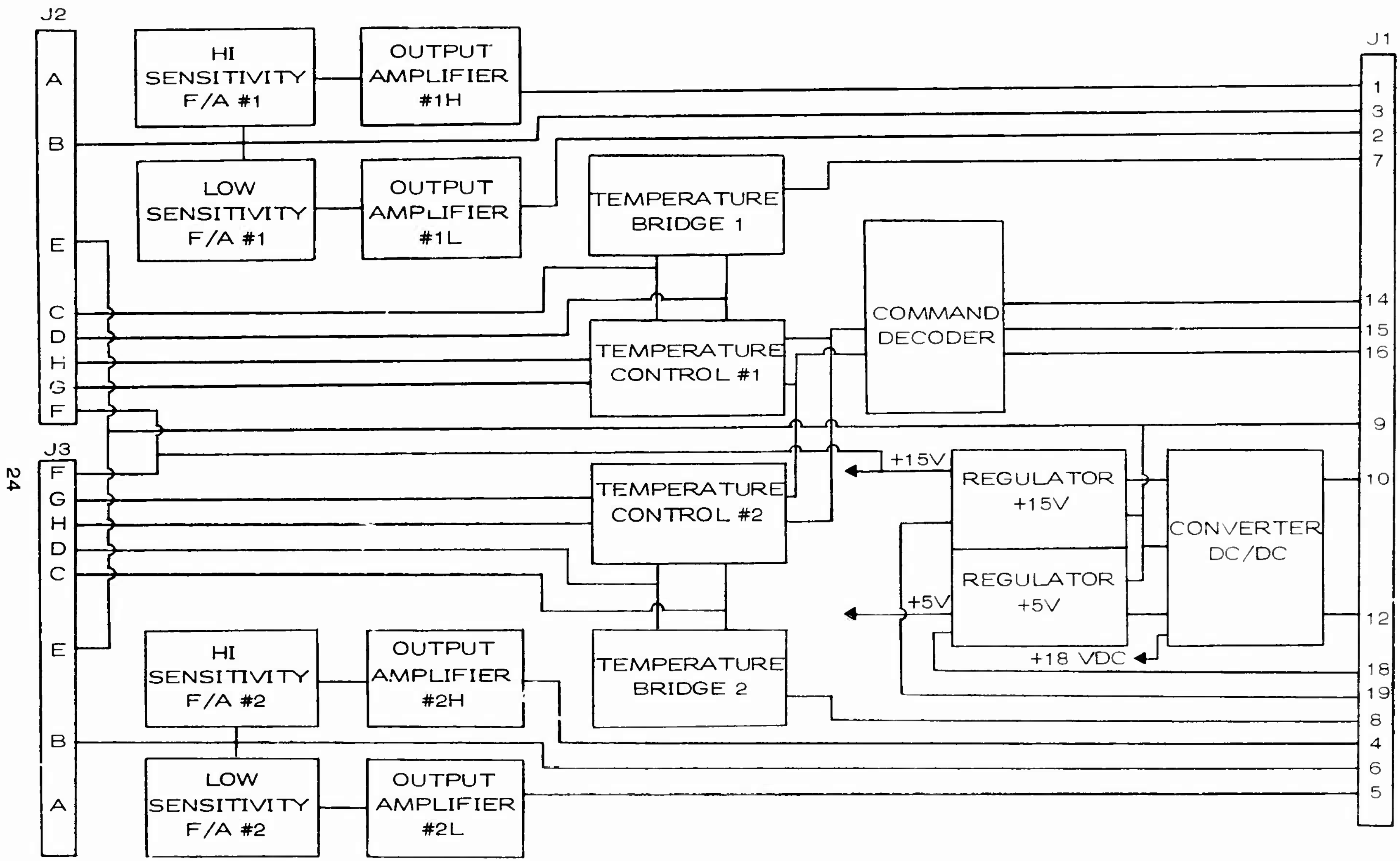

REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
B CHANGE PIN NOMENCLATURE P1 8/31
C CHANGE PIN NOMENCLATURE P1 10/31
TQCM SENSOR (IN HEAD) ML12-6
P6 J6
HEATER #1 RET
SENSOR XTAL
GROUND
TEMP #1
REFERENCE XTAL
HEATER #1
TEMP #1 RET
TQCM ELEC-TRONICS (IN HEAD) ML12-6
J4 P4
SHD GROUND
FREQ #1 OUT
TEMP #1
TEMP #1 RET
SIG GROUND
+15 VOLTS
HEATER #1
HEATER #1 RET
P2 J2
TQCM CON-TROLLER ML12-8
J1 P1
MASS #1 HIGH
MASS #1 LOW
FREQ #1
MASS #2 HIGH
MASS #2 LOW
FREQ #2
TEMP #1
TEMP #2
SIGNAL GROUND
+28 VOLTS
NO CONNECTION
POWER GROUND
NO CONNECTION
TEMP COMM
COMM CLOCK
COMM ENABLE
NO CONNECTION
5 V MONITOR
15 V MONITOR
TQCM SENSOR (IN HEAD) ML12-7
P7 J7
HEATER #2 RET
SENSOR XTAL
GROUND
TEMP #2
REFERENCE XTAL
HEATER #2
TEMP #2 RET
TQCM ELEC-TRONICS (IN HEAD) ML12-7
J5 P5
SHD GROUND
FREQ #2 OUT
TEMP #2
TEMP #2 RET
SIG GROUND
+15 VOLTS
HEATER #2
HEATER #2 RET
P3 J3
CONNECTORS
J1, LJTSIY-13-22P
P1, LJT06RE-13-22S(011)
J2, 3, 4 & 5, JTIH-12-8P(150)
P2, 3, 4 & 5, JT06RE-12-8S(011)
J6 & 7, FAR-1-7S-D
P6 & 7, FAR-1-7P-G
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM. BEFORE/AFTER FINISH
DIMENSIONS ARE IN INCHES
TOLERANCES
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
FINISH
NEXT ASSY
USED ON
APPLICATION
DASH NO.
RELEASED 5-5-76
Faraday Laboratories Inc.
TQCM SYSTEM
ELECTRONICS
INTERCONNECT
SIZE B
CODE IDENT NO.
DRAWING NO.
FL-76-120-C
SCALE
SHEET

Figure 19



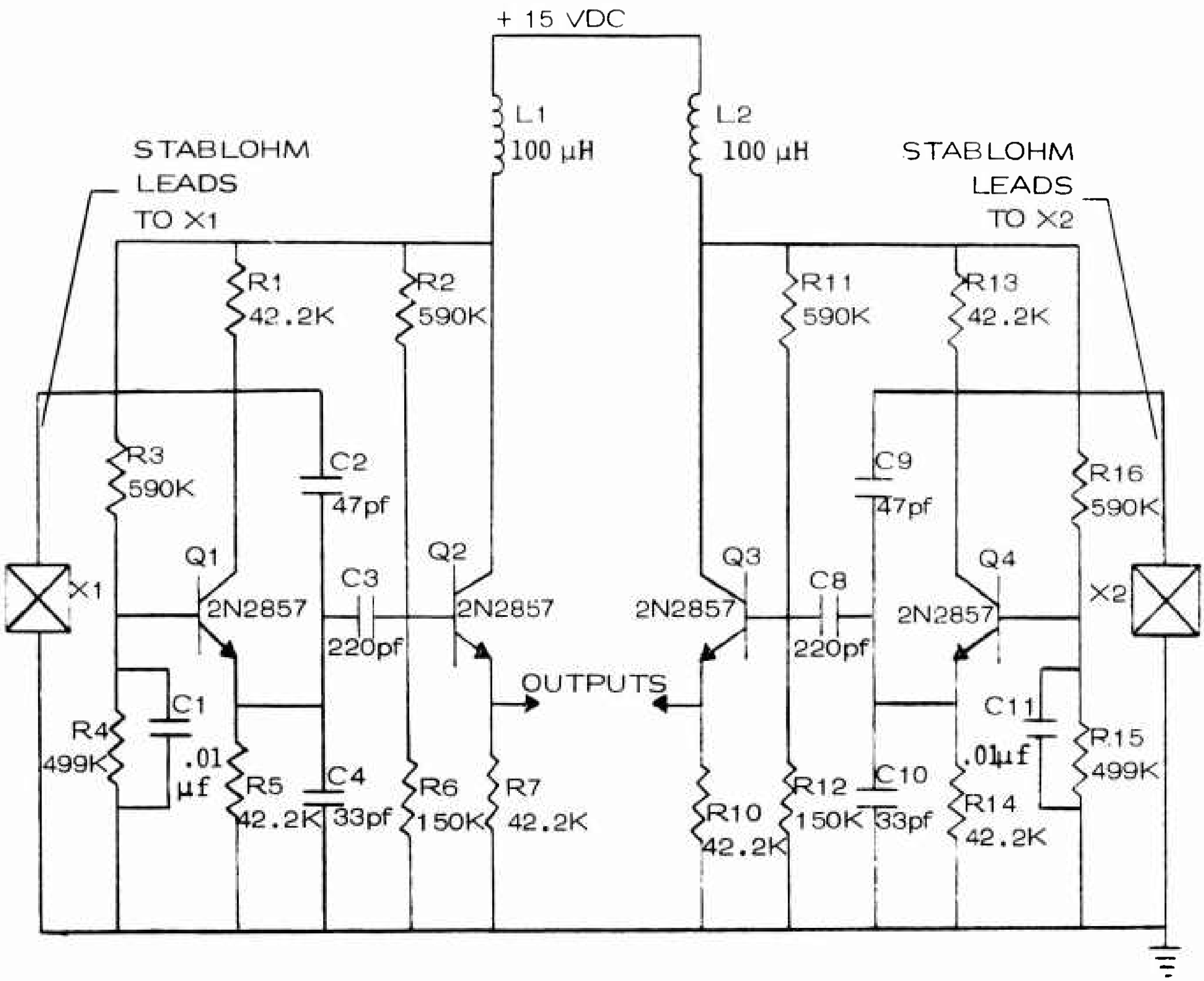
TQCM HEAD ELECTRONICS BLOCK DIAGRAM

Figure 20



TQCM CONTROLLER ELECTRONICS BLOCK DIAGRAM

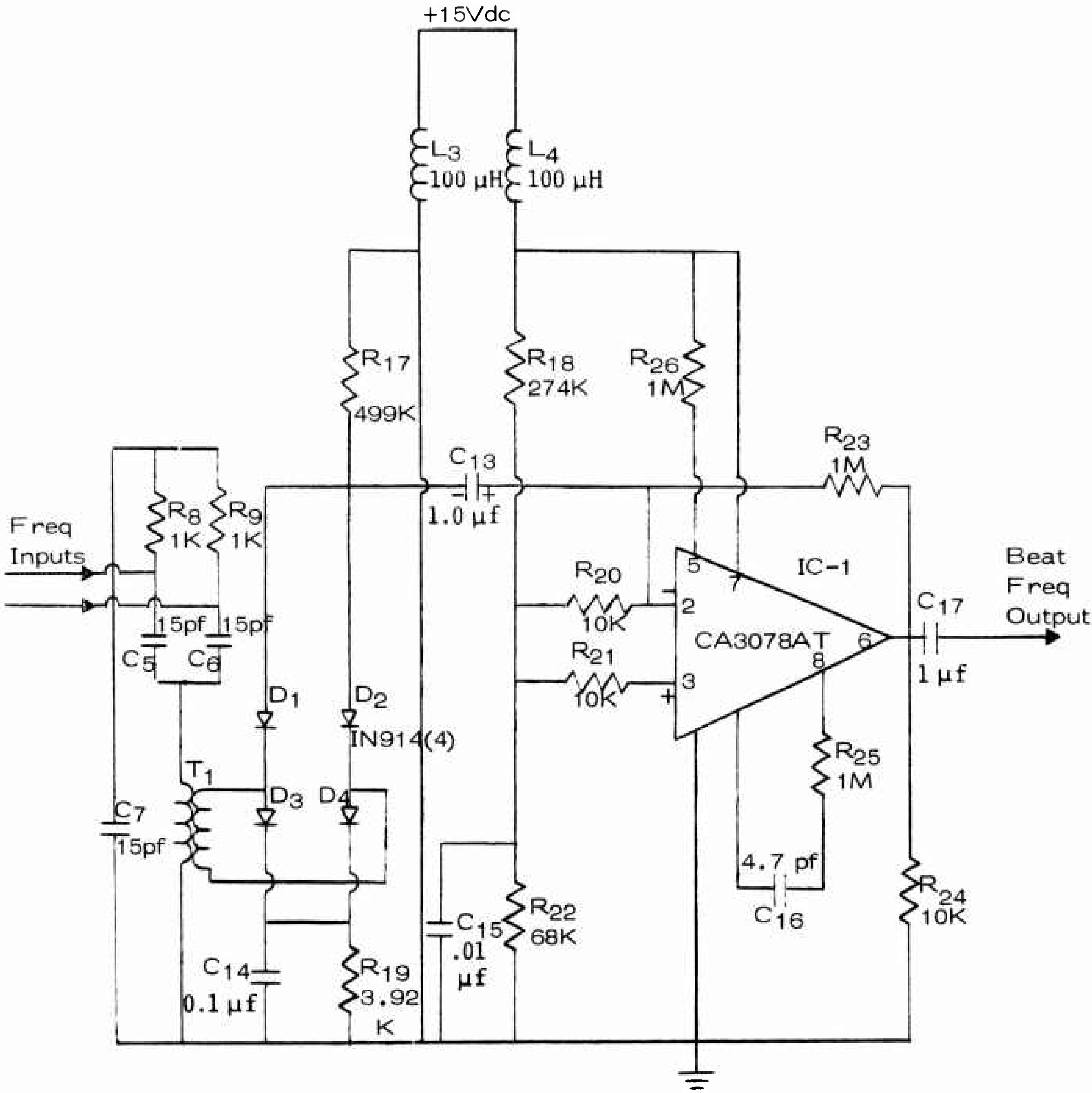
Figure 21



X1 - 15 MHz QUARTZ CRYSTAL (SENSOR)
X2 - 15 MHz QUARTZ CRYSTAL (REF)

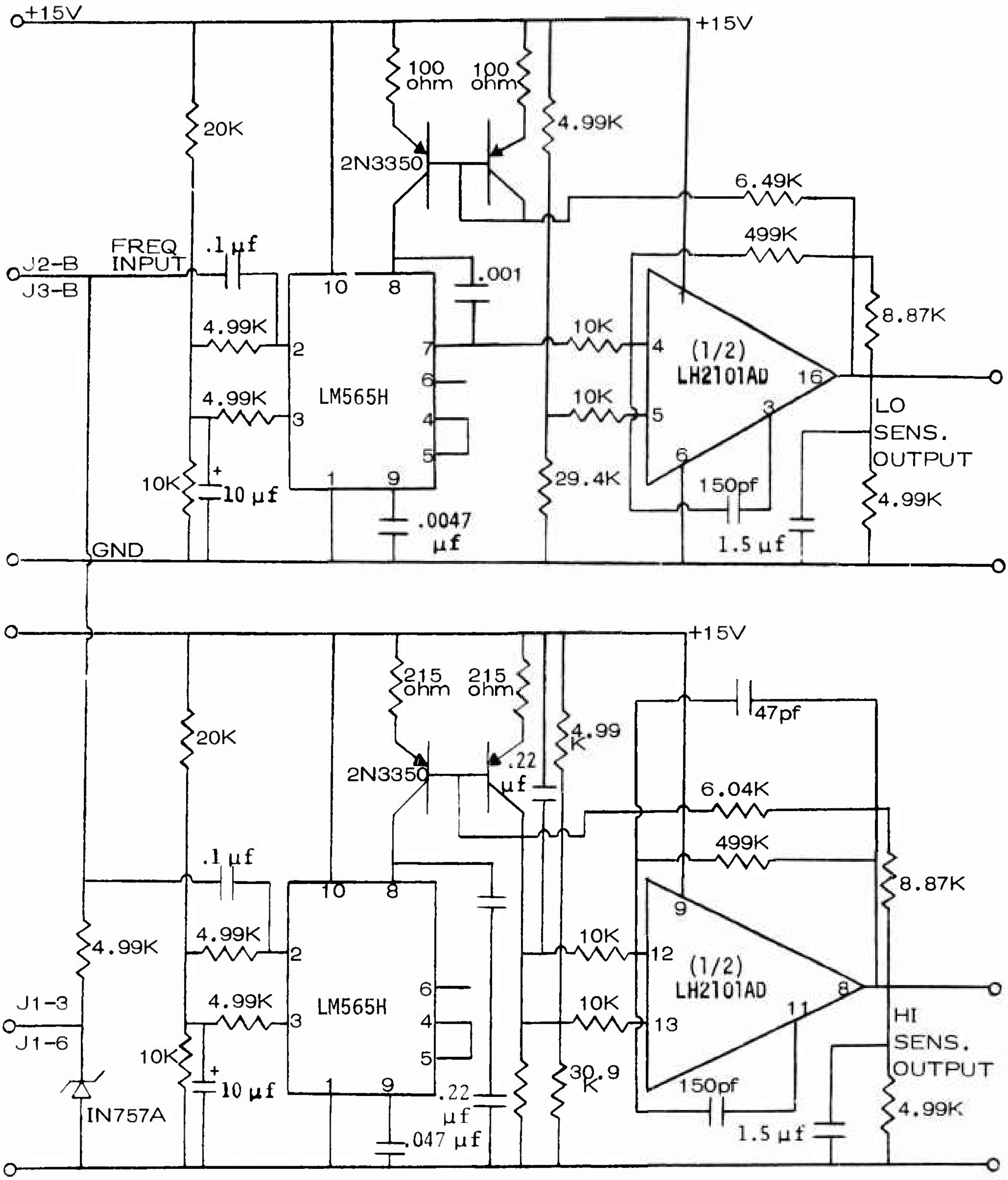
TQCM HEAD MATCHED 15-MHz OSCILLATORS

Figure 22



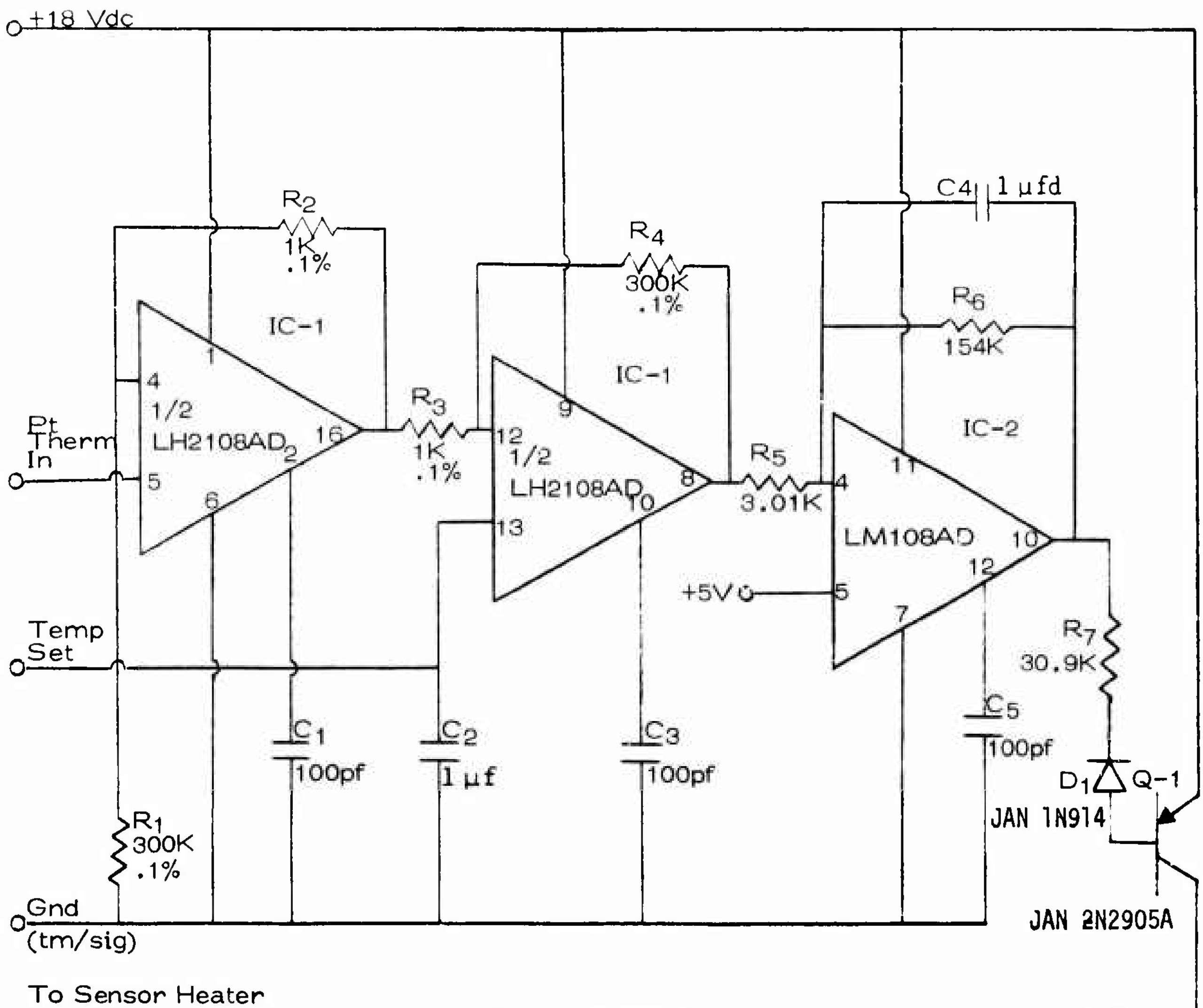
TQCM HEAD MIXER AND OUTPUT AMPLIFIER

Figure 23



TQCM CONTROLLER FREQ/VOLT CONVERTERS

Figure 24



TQCM CONTROLLER HEATER DRIVER

Figure 25

provided the signal to maintain a commanded set temperature. The bridge is shown in Figure 26.

4.6 Command Electronics

The decoder for input temperature commands is shown in Figure 27. The Zener capacitor network on the clock, enable, and data lines protects the decoder from input voltage surges.

The relay network is driven by the decoder for operating the heater driver. It is shown in Figure 28.

4.7 Power Supply

The TQCM requires a highly stable DC/DC isolation from satellite +28 ±4 Vdc power. Separate high and low power outputs for electronics and heaters are needed. The high-efficient, switching supply, manufactured for Faraday Laboratories Inc. by Transistor Devices Inc., is shown in Figure 29.

5.0 Calibration

5.1 Mass Sensor

The heart of the TQCM is its high mass sensitivity 15-MHz mass sensor. The design goal for sensor temperature vs frequency stability was ±75 between −60 and +60°C. This difficult objective was exceeded for the two sensors. Table 1 shows the matched crystals to have stabilities of ±35 Hz and ±14 Hz between -60 and +60°C.

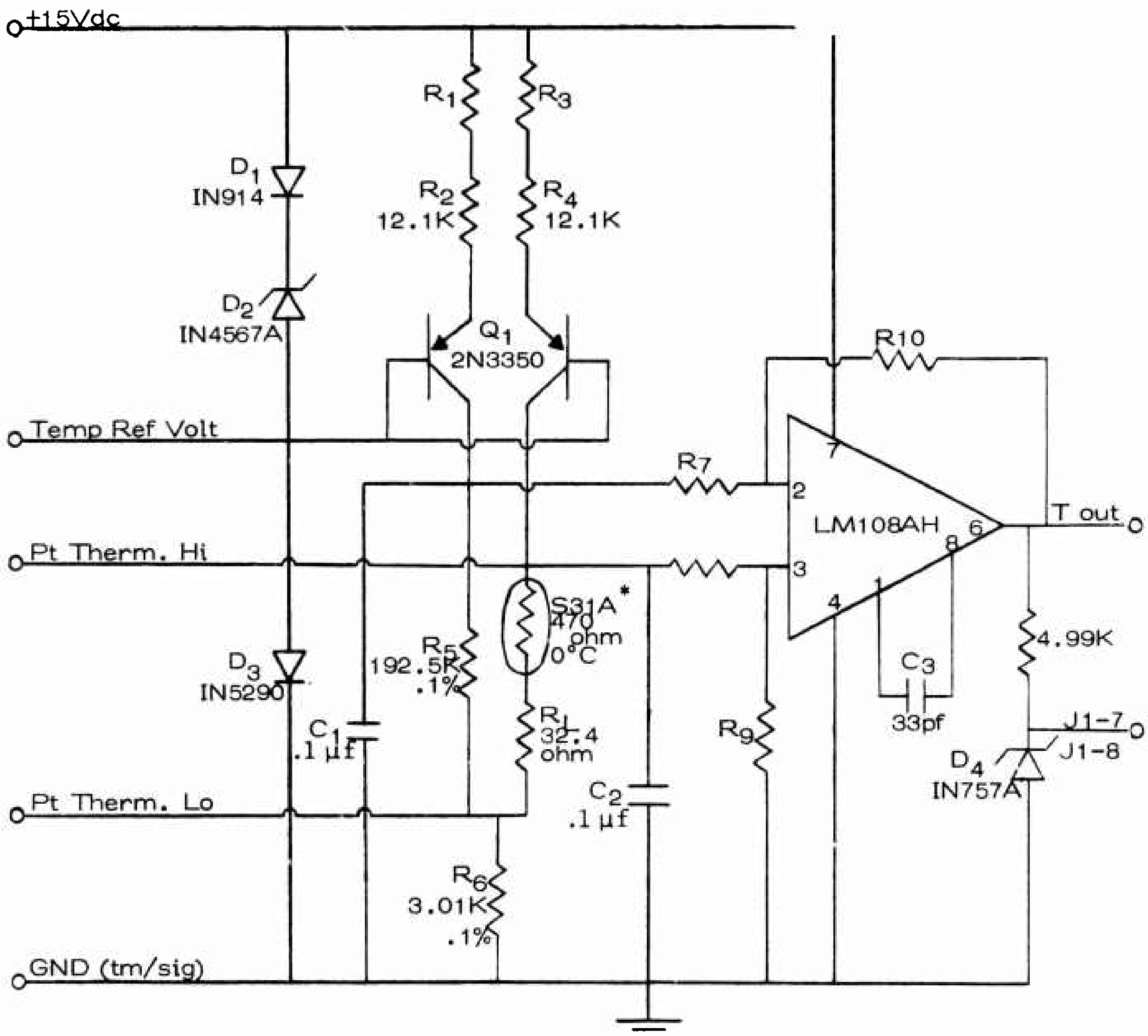
Frequency vs temperature plots for the crystal sets used in TQCM Heads 1 and 2 respectively are shown between −60 and +100°C in Figure 30.

After the sensors were calibrated, the sensor crystals were overplated with aluminum to give the matched set a beat frequency of 2kHz required for driving the F/A converters.

5.2 Controller

Calibration data of the TQCM Controller outputs for various input voltages at various ambient temperatures are shown in Tables 2 - 14.

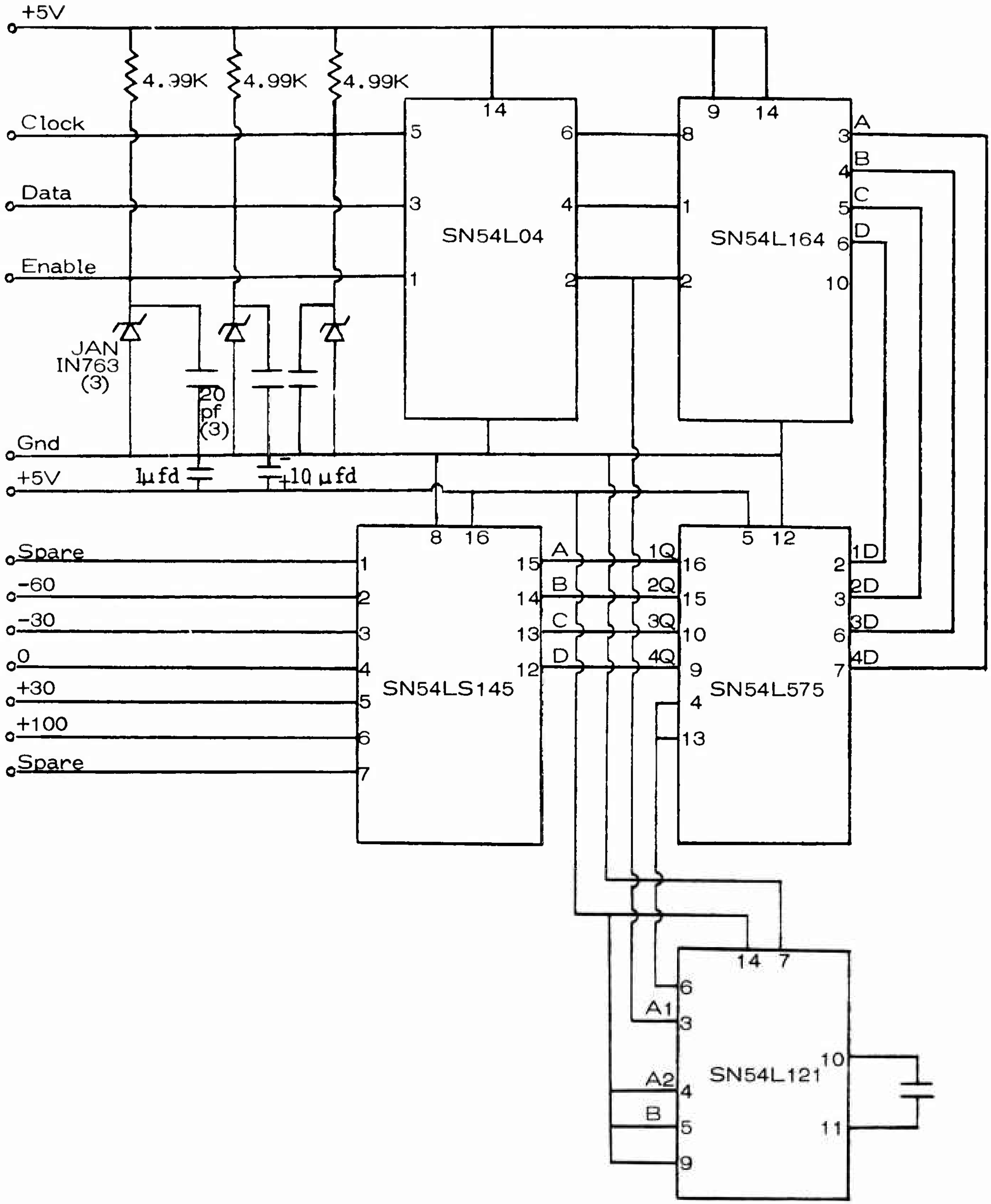
The tabulated calibration data are plotted in Figures 31 - 37 for TQCM Heads 1 and 2. Ambient temperature variations and input voltage changes are not called out in the figures. Changes in voltage and temperature produce Controller output changes of less than a few per cent and are



* Pt Thermometer
in TQCM Head

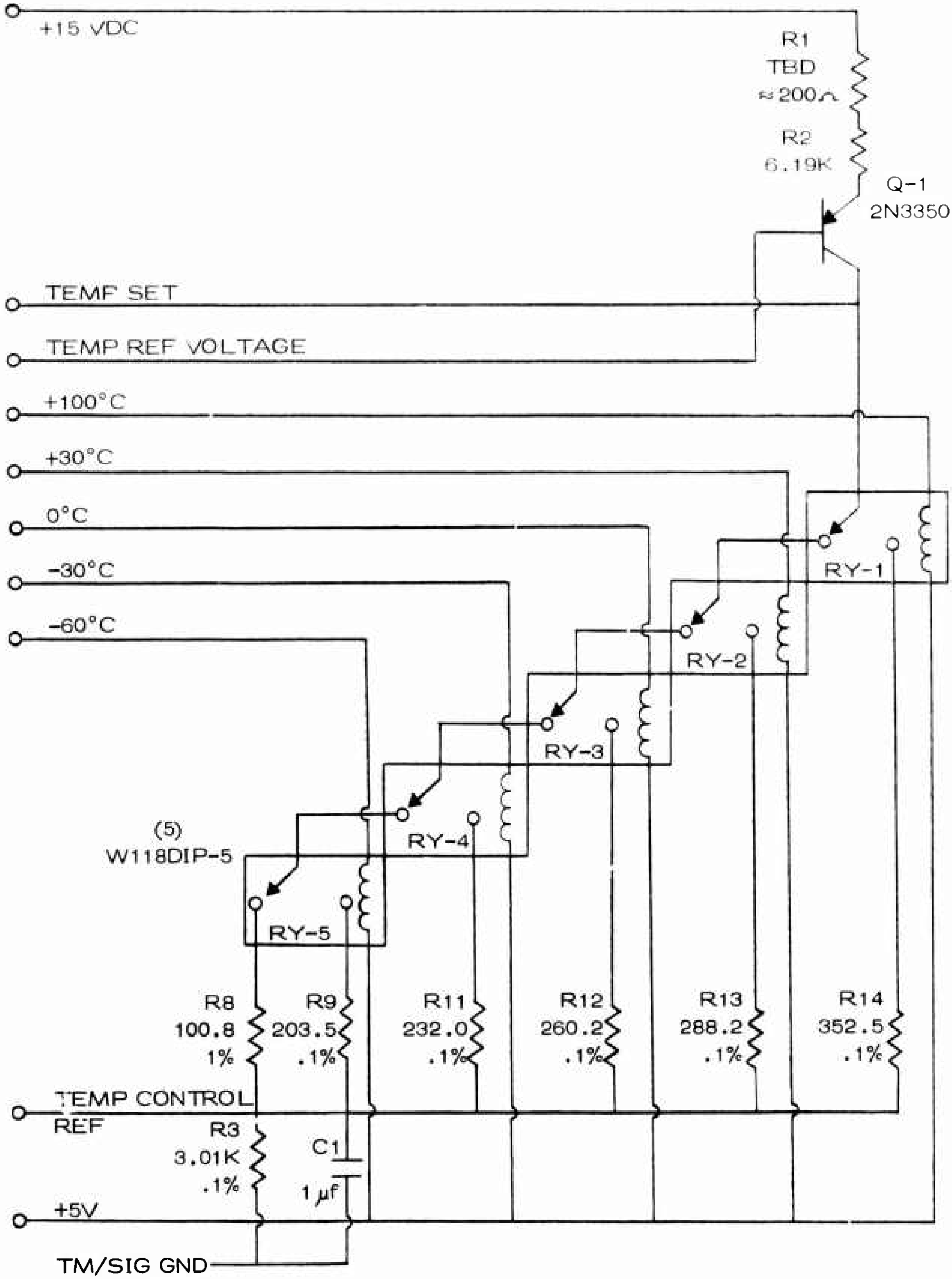
TQCM CONTROLLER TEMP BRIDGE

Figure 26



TQCM CONTROLLER SERIAL COMMAND DECODER

Figure 27



TQCM CONTROLLER DECODER RELAY NETWORK

Figure 28

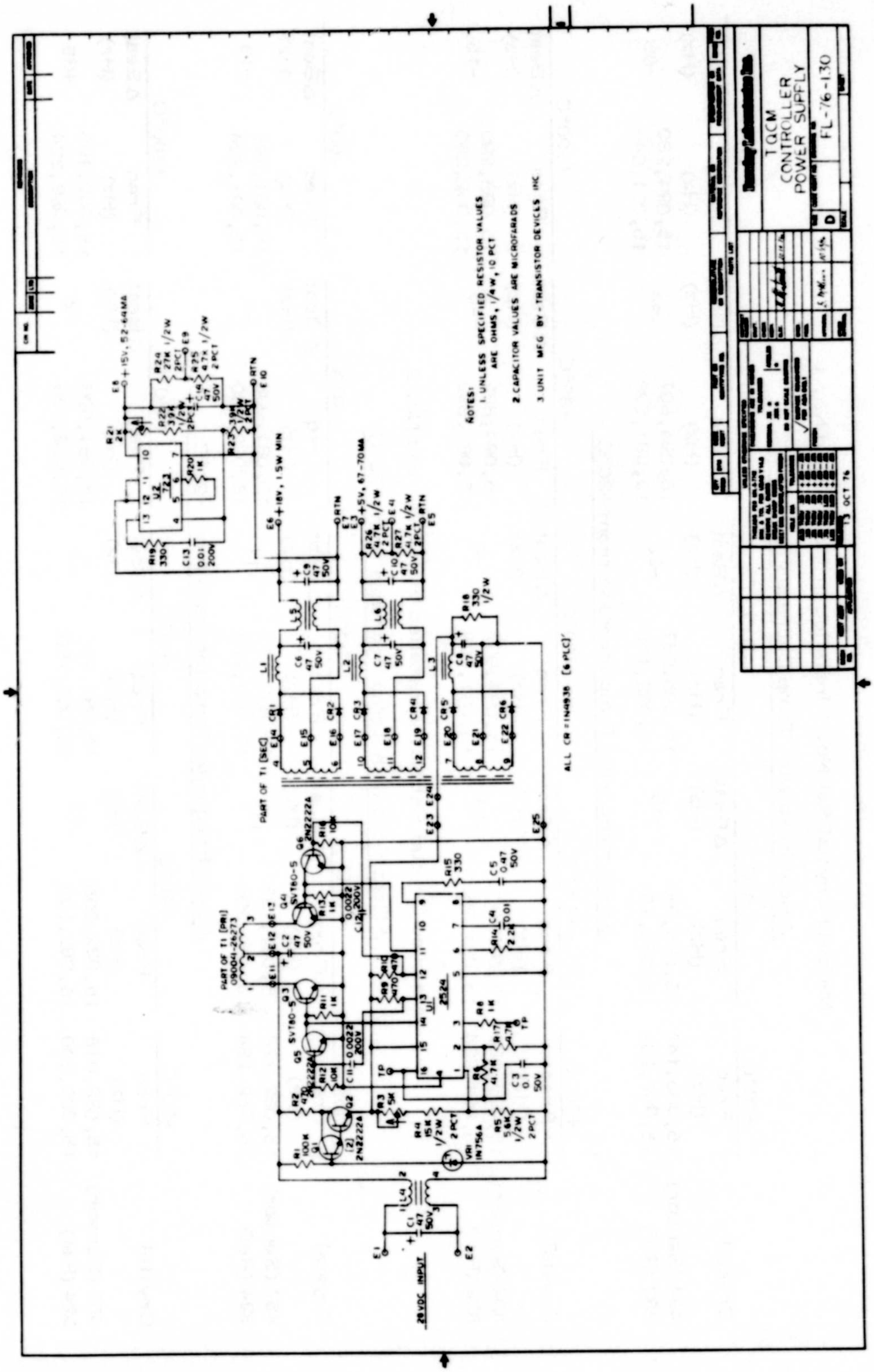

28VDC INPUT
ALL CR=1N4938 (6 PLC)
NOTES:
1. UNLESS SPECIFIED RESISTOR VALUES ARE OHMS, 1/4W, 10 PCT
2 CAPACITOR VALUES ARE MICROFARADS
3 UNIT MFG BY-TRANSISTOR DEVICES INC
TQCM
CONTROLLER
POWER SUPPLY
FL-76-130
13 OCT 76

Figure 29

Table 1 Freq vs Temp Calibration of TQCM 15-MHz Sensor Crystals in 1 x 10^{-7} Torr Vacuum

Matched Crystal Set No. 1 Installed in TQCM Head No. 1

ΔBeat Freq with Temp Decrease from +20°C

Crystal	+20°C Freq (Hz)	0°C Freq (Hz)	0°C ΔBeat (Hz)	-20°C Freq (Hz)	-20°C ΔBeat (Hz)	-40°C Freq (Hz)	-40°C ΔBeat (Hz)	-60°C Freq (Hz)	-60°C ΔBeat (Hz)
494 (Sensor)	15,095,145	15,095,082	-19	15,095,087	-22	15,094,837	-36	15,094,230	-66
333 (Ref)	15,082,204	15,082,151		15,082,159		15,081,923		15,081,346	

ΔBeat Freq with Temp Increase from +20°C

Crystal	+20°C Freq (Hz)	+40°C Freq (Hz)	+40°C ΔBeat (Hz)	+60°C Freq (Hz)	+60°C ΔBeat (Hz)	+80°C Freq (Hz)	+80°C ΔBeat (Hz)	+100°C Freq (Hz)	+100°C ΔBeat (Hz)
494 (Sensor)	15,095,030	15,095,002	+4	15,094,937	-8	15,094,882	-46	15,095,290	-15
333 (Ref)	15,081,994	15,081,962		15,081,909		15,081,892		15,082,269	

Matched Crystal Set No. 2 Installed in TQCM Head No. 2

ΔBeat Freq with Temp Decrease from +20°C

Crystal	+20°C Freq (Hz)	0°C Freq (Hz)	0°C ΔBeat (Hz)	-20°C Freq (Hz)	-20°C ΔBeat (Hz)	-40°C Freq (Hz)	-40°C ΔBeat (Hz)	-60°C Freq (Hz)	-60°C ΔBeat (Hz)
457 (Sensor)	15,082,128	15,082,123	+15	15,082,111	+11	15,081,908	-4	15,081,241	-13
324 (Ref)	15,082,284	15,082,294		15,082,278		15,082,060		15,081,394	

ΔBeat Freq with Temp Increase from +20°C

Crystal	+20°C Freq (Hz)	+40°C Freq (Hz)	+40°C ΔBeat (Hz)	+60°C Freq (Hz)	+60°C ΔBeat (Hz)	+80°C Freq (Hz)	+80°C ΔBeat (Hz)	+100°C Freq (Hz)	+100°C ΔBeat (Hz)
457 (Sensor)	15,082,018	15,082,005	+3	15,081,976	-7	15,081,993	+2	15,082,105	+38
324 (Ref)	15,082,209	15,082,199		15,082,160		15,082,186		15,082,324	

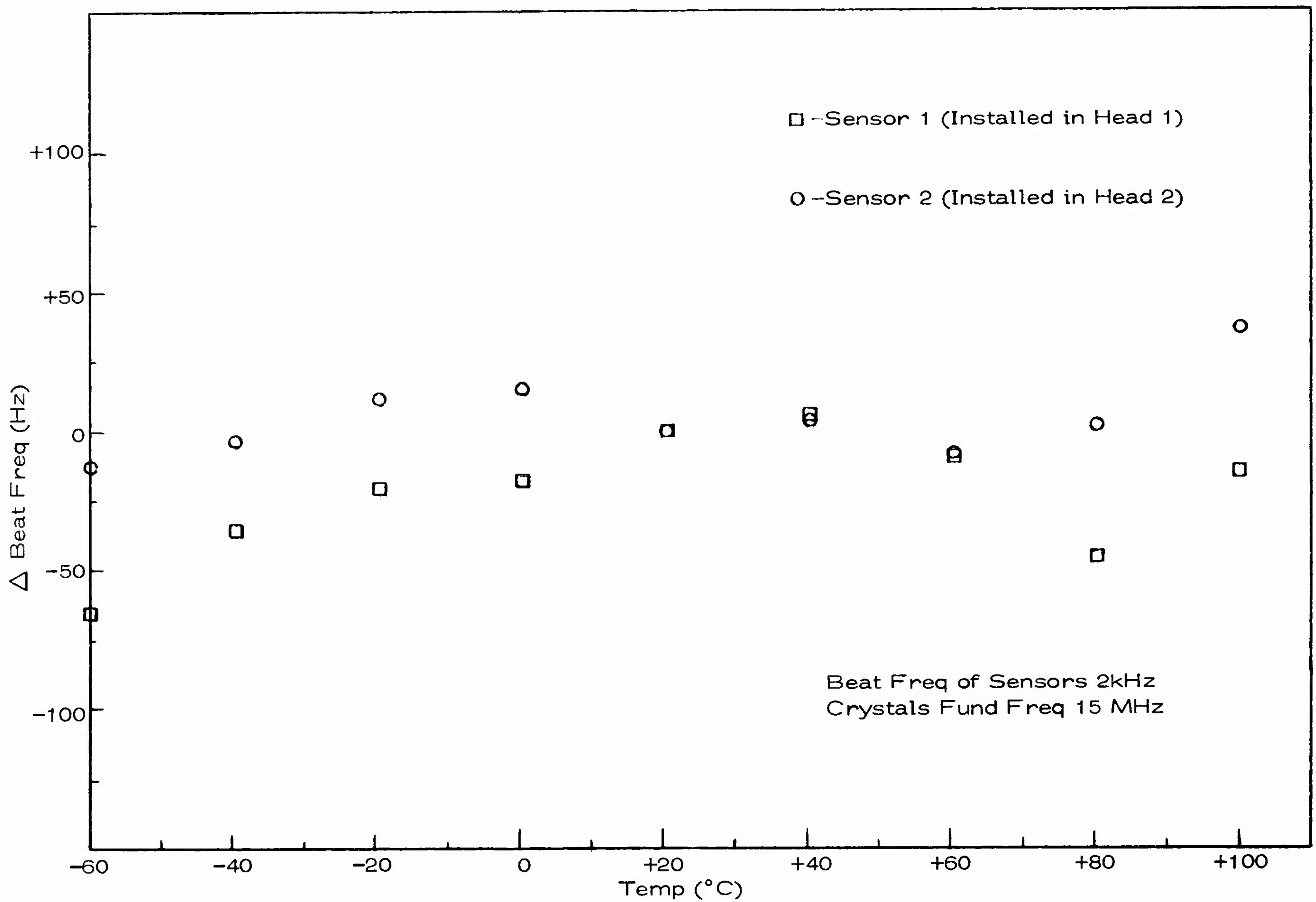


Figure 30 TQCM Sensors Frequency vs Temperature Calibration

Table 2 TQCM Freq/Volt Converter Output at 0°C Ambient for Input Power Voltage of +28 Vdc ± 4V. Sensor Beat Freq at Zero Loading 2KHz

Sensor Beat Freq Change	Mass Loading Change	Hi-Sens. Out. No. 1	Lo-Sens. Out. No. 1	Hi-Sens. Out. No. 2	Lo-Sens. Out. No. 2
(Hz)	($g/cm^2 \times 10^{-6}$)	(V)	(V)	(V)	(V)
-200	0.312	4.87	5.07	4.97	5.05
-150	0.234	4.72	5.07	4.80	5.05
-100	0.156	4.56	5.06	4.64	5.05
-50	0.078	4.40	5.06	4.48	5.04
0	0	4.24	5.06	4.31	5.04
100	0.156	3.94	5.05	4.00	5.03
200	0.312	3.62	5.04	3.67	5.02
300	0.468	3.31	5.03	3.35	5.01
400	0.624	2.99	5.03	3.02	5.00
500	0.780	2.67	5.02	2.69	5.00
600	0.936	2.36	5.01	2.37	4.99
700	1.092	2.04	5.00	2.04	4.98
800	1.248	1.73	5.00	1.72	4.98
900	1.404	1.41	4.99	1.39	4.97
1,000	1.560	1.09	4.98	1.06	4.96
1,100	1.716	.77	4.97	.73	4.95
1,200	1.872		4.96		4.94
3,000	4.680		4.83		4.81
8,000	12.480		4.43		4.41
18,000	28.080		3.66		3.63
28,000	43,680		2.88		2.85
38,000	59.280		2.11		2.07
48,000	74.880		1.34		1.29
58,000	90.480		.68		.66
59,000	92.040		.63		.62
60,000	93.60		.57		.56

Table 3 TQCM Freq/Volt Converter Output at +20°C Ambient for Input Power Voltage of +28 Vdc ± 4V. Sensor Beat Freq at Zero Loading 2KHz

Sensor Beat Freq Change (Hz)	Mass Loading Change ($g/cm^2 \times 10^{-6}$)	Hi-Sens. Out. No. 1 (V)	Lo-Sens. Out. No. 1 (V)	Hi-Sens. Out. No. 2 (V)	Lo-Sens. Out. No. 2 (V)
-200	0.312	5.06	5.09	5.15	5.07
-150	0.234	4.90	5.09	5.00	5.07
-100	0.156	4.75	5.08	4.83	5.06
-50	0.078	4.60	5.08	4.68	5.06
0	0	4.45	5.07	4.52	5.06
100	0.156	4.14	5.07	4.20	5.05
200	0.312	3.84	5.06	3.89	5.04
300	0.468	3.53	5.05	3.57	5.03
400	0.624	3.22	5.05	3.25	5.03
500	0.780	2.92	5.04	2.94	5.02
600	0.936	2.61	5.03	2.62	5.01
700	1.092	2.30	5.02	2.31	5.00
800	1.248	1.99	5.01	1.99	4.99
900	1.404	1.68	5.01	1.67	4.99
1,000	1.560	1.38	5.00	1.35	4.90
1,100	1.716	1.07	4.99	1.04	4.97
1,200	1.872	.76	4.98		4.96
3,000	4.680		4.84		4.82
8,000	12.480		4.45		4.43
18,000	28.080		3.67		3.65
28,000	43.680		2.90		2.86
38,000	59.280		2.12		2.09
48,000	74.880		1.35		1.30
58,000	90.480		.68		.66
59,000	92.040		.63		.62
60,000	93.60		.56		.55

Table 4 TQCM Freq/Volt Converter Output at +30°C Ambient for Input Power Voltage of +28 Vdc ± 4V. Sensor Beat Freq at Zero Loading 2KHz

Sensor Beat Freq Change (Hz)	Mass Loading Change ($g/cm^2 \times 10^{-6}$)	Hi-Sens. Out. No. 1 (V)	Lo-Sens. Out. No. 1 (V)	Hi-Sens. Out. No. 2 (V)	Lo-Sens. Out. No. 2 (V)
-200	0.312	5.05	5.09	5.15	4.94
-150	0.234	4.90	5.09	4.99	5.08
-100	0.156	4.74	5.09	4.84	5.07
-50	0.078	4.59	5.08	4.67	5.07
0	0	4.44	5.08	4.52	5.06
100	0.156	4.14	5.07	4.21	5.05
200	0.312	3.83	5.06	3.89	5.04
300	0.468	3.52	5.06	3.58	5.04
400	0.624	3.21	5.05	3.26	5.03
500	0.780	2.90	5.04	2.94	5.02
600	0.936	2.59	5.03	2.62	5.02
700	1.092	2.28	5.02	2.30	5.01
800	1.248	1.98	5.02	1.98	5.00
900	1.404	1.67	5.01	1.66	4.99
1,000	1.560	1.35	5.00	1.34	4.98
1,100	1.716	1.05	4.99	1.03	4.98
1,200	1.872	.74	4.98		4.97
3,000	4.680		4.85		4.83
8,000	12.480		4.46		4.44
18,000	28.080		3.67		3.65
28,000	43.680		2.90		2.87
38,000	59.280		2.12		2.09
48,000	74.880		1.35		1.31
58,000	90.480		.68		.66
59,000	92.040		.62		.62
60,000	93.60		.56		.55

Table 5 TQCM Freq/Volt Converter Output at +50°C Ambient for Input Power Voltage of +28 Vdc ± 4V. Sensor Beat Freq at Zero Loading 2KHz

Sensor Beat Freq Change (Hz)	Mass Loading Change ($g/cm^2 \times 10^{-6}$)	Hi-Sens. Out. No. 1 (V)	Lo-Sens. Out. No. 1 (V)	Hi-Sens. Out. No. 2 (V)	Lo-Sens. Out. No. 2 (V)
-200	0.312	5.16	5.12	4.96	4.84
-150	0.234	5.01	5.11	4.95	5.12
-100	0.156	4.86	5.11	4.97	4.95
-50	0.078	4.71	5.10	4.81	4.99
0	0	4.56	5.10	4.66	5.08
100	0.156	4.26	5.09	4.36	5.07
200	0.312	3.96	5.09	4.05	5.06
300	0.468	3.65	5.08	3.73	5.06
400	0.624	3.35	5.07	3.42	5.05
500	0.780	3.04	5.06	3.10	5.04
600	0.936	2.73	5.05	2.79	5.04
700	1.092	2.43	5.04	2.48	5.03
800	1.248	2.12	5.03	2.16	5.02
900	1.404	1.81	5.03	1.85	5.01
1,000	1.560	1.51	5.02	1.54	5.00
1,100	1.716	1.21	5.01	1.22	4.99
1,200	1.872	.90	5.01	.91	4.99
3,000	4.680		4.87		4.85
8,000	12.480		4.47		4.45
18,000	28.080		3.69		3.67
28,000	43.680		2.91		2.88
38,000	59.280		2.13		2.10
48,000	74.880		1.35		1.32
58,000	90.480		.67		.67
59,000	92.040		.61		.61
60,000	93.60		.54		.54

Table 6 TQCM Temp Outputs for Different Input Power Voltages at 0°C Ambient

	+32 Vdc		+28 Vdc		+24 Vdc	
Temp	Temp Output #1	Temp Output #2	Temp Output #1	Temp Output #2	Temp Output #1	Temp Output #2
(°C)	(V)	(V)	(V)	(V)	(V)	(V)
-110	1.00	1.03	1.00	1.03	1.00	1.03
-100	1.20	1.23	1.20	1.23	1.20	1.22
- 73	1.72	1.75	1.72	1.75	1.72	1.75
- 23	2.67	2.70	2.68	2.70	2.67	2.70
0	3.11	3.13	3.11	3.13	3.11	3.13
+ 27	3.61	3.64	3.61	3.64	3.61	3.64
+ 52	4.08	4.10	4.08	4.10	4.08	4.10
+100	4.96	4.98	4.96	4.98	4.96	4.98
+110	5.14	5.17	5.14	5.17	5.14	5.17

Table 7 TQCM Temp Outputs for Different Input Power Voltages at +20°C Ambient

	+32 Vdc		+28 Vdc		+24 Vdc	
Temp	Temp Output #1	Temp Output #2	Temp Output #1	Temp Output #2	Temp Output #1	Temp Output #2
(°C)	(V)	(V)	(V)	(V)	(V)	(V)
-110	1.00	1.03	1.00	1.03	1.00	1.03
-100	1.20	1.23	1.20	1.23	1.20	1.23
- 73	1.72	1.75	1.72	1.75	1.72	1.75
- 23	2.68	2.70	2.68	2.70	2.68	2.70
0	3.11	3.13	3.11	3.13	3.11	3.13
+ 27	3.62	3.63	3.62	3.64	3.62	3.64
+ 52	4.08	4.10	4.08	4.10	4.08	4.10
+100	4.96	4.98	4.96	4.98	4.96	4.98
+110	5.15	5.17	5.15	5.16	5.15	5.17

Table 8 TQCM Temp Outputs for Different Input Power Voltages at +30°C Ambient

	+32 Vdc		+28 Vdc		+24 Vdc	
Temp	Temp Output #1	Temp Output #2	Temp Output #1	Temp Output #2	Temp Output #1	Temp Output #2
(°C)	(V)	(V)	(V)	(V)	(V)	(V)
−110	1.00	1.03	1.00	1.03	1.00	1.03
−100	1.20	1.23	1.20	1.23	1.20	1.23
− 73	1.72	1.75	1.72	1.75	1.72	1.75
− 23	2.68	2.70	2.68	2.70	2.68	2.70
0	3.11	3.14	3.11	3.14	3.11	3.14
+ 27	3.62	3.64	3.62	3.64	3.62	3.64
+ 52	4.08	4.10	4.08	4.10	4.08	4.10
+100	4.97	4.99	4.97	4.99	4.97	4.99
+110	5.15	5.17	5.15	5.17	5.15	5.17

Table 9 TQCM Temp Outputs for Different Input Power Voltages at +50°C Ambient

	+32 Vdc		+28 Vdc		+24 Vdc	
Temp	Temp Output #1	Temp Output #2	Temp Output #1	Temp Output #2	Temp Output #1	Temp Output #2
(°C)	(V)	(V)	(V)	(V)	(V)	(V)
-110	1.01	1.03	1.01	1.03	1.01	1.03
-100	1.20	1.23	1.20	1.23	1.20	1.23
- 73	1.73	1.75	1.73	1.75	1.73	1.75
- 23	2.68	2.70	2.68	2.70	2.68	2.70
0	3.12	3.13	3.11	3.13	3.12	3.13
+ 27	3.62	3.64	3.62	3.63	3.62	3.64
+ 52	4.09	4.10	4.09	4.10	4.09	4.10
+100	4.97	4.98	4.97	4.98	4.97	4.98
+110	5.15	5.16	5.15	5.16	5.15	5.16

Table 10 TQCM Commanded and Operating Temp for Different Input Voltages and Ambient Temperatures

Command Temp (°C)	+32 Vdc TQCM No. 1 (°C)	+32 Vdc TQCM No. 2 (°C)	+28 Vdc TQCM No. 1 (°C)	+28 Vdc TQCM No. 2 (°C)	+24 Vdc TQCM No. 1 (°C)	+24 Vdc TQCM No. 2 (°C)
0°C						
-60	-58.8	-58.9	-58.9	-59.1	-59.2	-59.2
-30	-31.7	-31.4	-31.4	-31.4	-31.5	-31.7
0	-0.6	-0.7	-0.7	-0.9	-0.9	-1.1
+30	+30.3	+30.0	+30.1	+29.8	+29.9	+29.7
+100	+102.1	+101.7	+101.9	+101.6	+101.7	+101.5
+20°C						
-60	-58.6	-58.6	-58.6	-58.6	-58.9	-58.9
-30	-31.2	-31.2	-31.4	-31.4	-31.6	-31.6
0	-0.7	-0.7	-0.7	-0.7	-0.9	-0.9
+30	+30.1	+30.2	+30.0	+30.1	+29.8	+30.0
+100	+101.2	+102.0	+101.5	+101.8	+101.5	+101.5
+30°C						
-60	-58.9	-58.9	-58.9	-58.9	-59.1	-59.1
-30	-31.3	-31.2	-31.4	-31.4	-31.6	-31.6
0	-0.6	-0.6	-0.7	-0.7	-0.9	-0.9
+30	+30.1	+30.1	+30.0	+30.0	+29.9	+29.9
+100	+101.8	+101.8	+101.7	+101.7	+101.5	+101.5
+50°C						
-60	-59.0	-58.7	-59.2	-58.9	-59.3	-59.2
-30	-31.4	-31.2	-31.4	-31.2	-31.7	-31.4
0	-0.7	-0.5	-0.9	-0.7	-1.1	-0.9
+30	+30.0	+30.3	+29.8	+30.1	+29.7	+29.9
+100	+101.8	+102.1	+101.7	+101.9	+101.5	+101.7

Table 11 Power Supply Calibration at 0°C Ambient

TQCM Electronics ON and Heaters OFF

Volts In (Vdc)	Current In (mA)	Power In (W)	+5V Monitor (Vdc)	+15V Monitor (Vdc)
24	91.0	2.184	2.58	2.22
28	82.0	2.296	2.57	2.22
32	72.5	2.304	2.57	2.22

TQCM Electronics and Heaters ON

Volts In (Vdc)	Electronics & Heater 1 (W)	Electronics & Heater 2 (W)	Electronics & Heaters 1 & 2 (W)	Monitors Max Pwr 5V (Vdc)	Monitors Max Pwr 15V (Vdc)
24	3.528	3.648	5.016	2.59	2.22
28	3.696	3.836	5.012	2.58	2.22
32	3.712	3.808	4.960	2.52	2.22

Note: Test points for monitoring +5V and +15V supplies are in series with voltage dividers to protect supplies from accidental grounding and possible burn out. Hence, values given indicate supplies are properly functioning.

Table 12 Power Supply Calibration at +20°C Ambient

TQCM Electronics ON and Heaters OFF

Volts In (Vdc)	Current In (mA)	Power In (W)	+5V Monitor (Vdc)	+15V Monitor (Vdc)
24	87.0	2.088	2.60	2.22
28	76.5	2.142	2.59	2.22
32	70.0	2.240	2.59	2.22

TQCM Electronics and Heaters ON

Volts In (Vdc)	Electronics & Heater 1 (W)	Electronics & Heater 2 (W)	Electronics & Heaters 1 & 2 (W)	Monitors Max Pwr 5V (Vdc)	Monitors Max Pwr 15V (Vdc)
24	3.62	3.72	5.09	2.57	2.22
28	3.81	3.86	5.07	2.57	2.22
32	3.87	3.93	5.09	2.49	2.22

Table 13 Power Supply Calibration at +30°C Ambient

TQCM Electronics ON and Heaters OFF

Volts In	Current In	Power In	+5V Monitor	+15V Monitor
(Vdc)	(mA)	(W)	(Vdc)	(Vdc)
24	87.0	2.088	2.60	2.22
28	77.0	2.156	2.59	2.22
32	70.0	2.240	2.59	2.22

TQCM Electronics and Heaters ON

Volts In	Electronics & Heater 1	Electronics & Heater 2	Electronics & Heaters 1 & 2	Monitors Max Pwr 5V	Monitors Max Pwr 15V
(Vdc)	(W)	(W)	(W)	(Vdc)	(Vdc)
24	3.528	3.576	4.968	2.60	2.22
28	3.695	3.752	4.984	2.60	2.22
32	3.680	3.712	4.960	2.63	2.22

Table 14 Power Supply Calibration at +50°C Ambient

TQCM Electronics ON and Heater OFF

Volts In	Current In	Power In	+5V Monitor	+15V Monitor
(Vdc)	(mA)	(W)	(Vdc)	(Vdc)
24	86.0	2.064	2.61	2.22
28	76.0	2.128	2.61	2.23
32	70.0	2.240	2.60	2.23

TQCM Electronics and Heaters ON

Volts In	Electronics & Heater 1	Electronics & Heater 2	Electronics & Heaters 1 & 2	Monitors Max Pwr 5V	Monitors Max Pwr 15V
(Vdc)	(W)	(W)	(W)	(Vdc)	(Vdc)
24	3.552	3.600	5.040	2.61	2.22
29	3.724	3.752	5.040	2.62	2.23
32	3.744	3.776	4.960	2.54	2.23

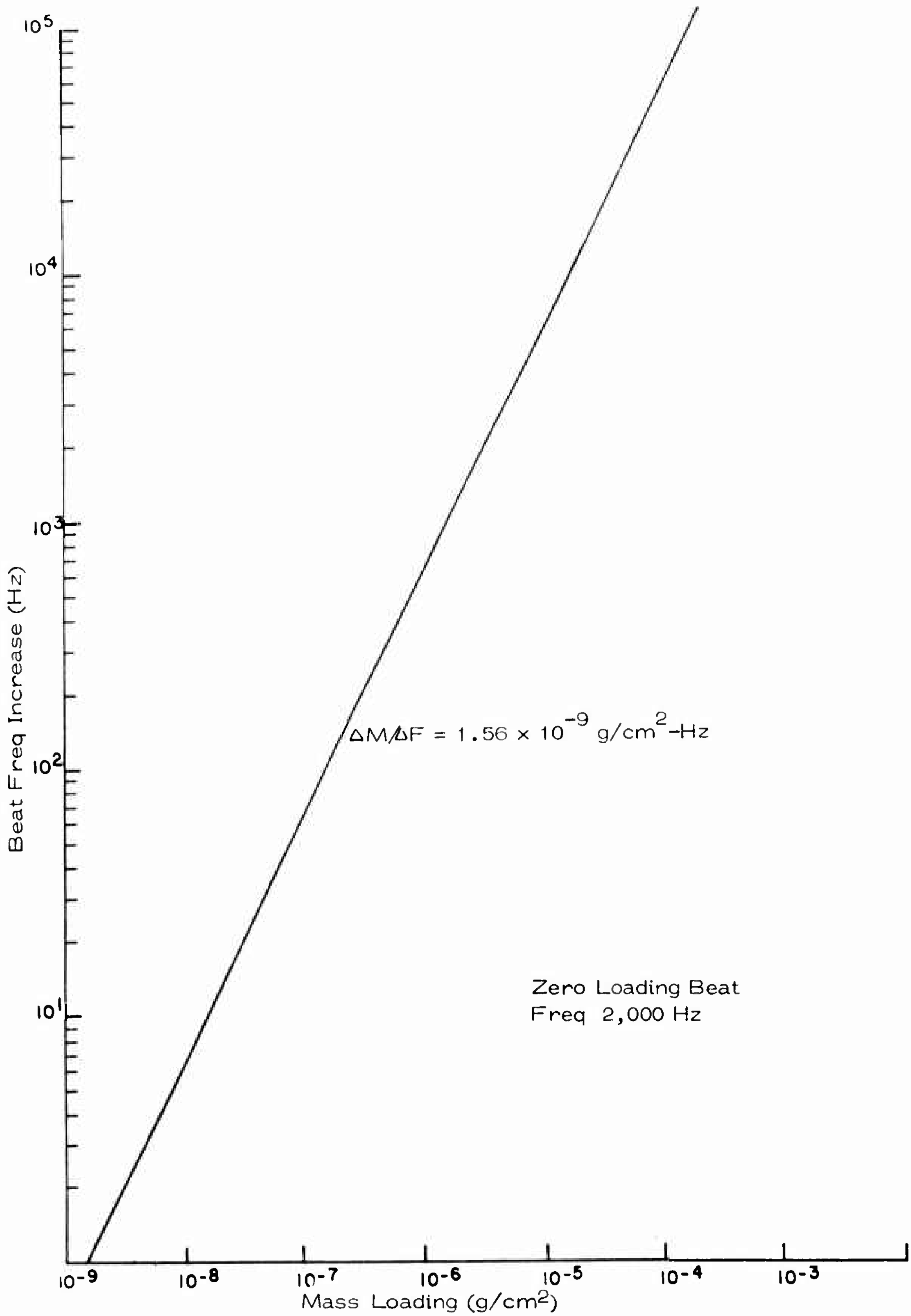


Figure 31 TQCM 15-MHz Sensor Calibration

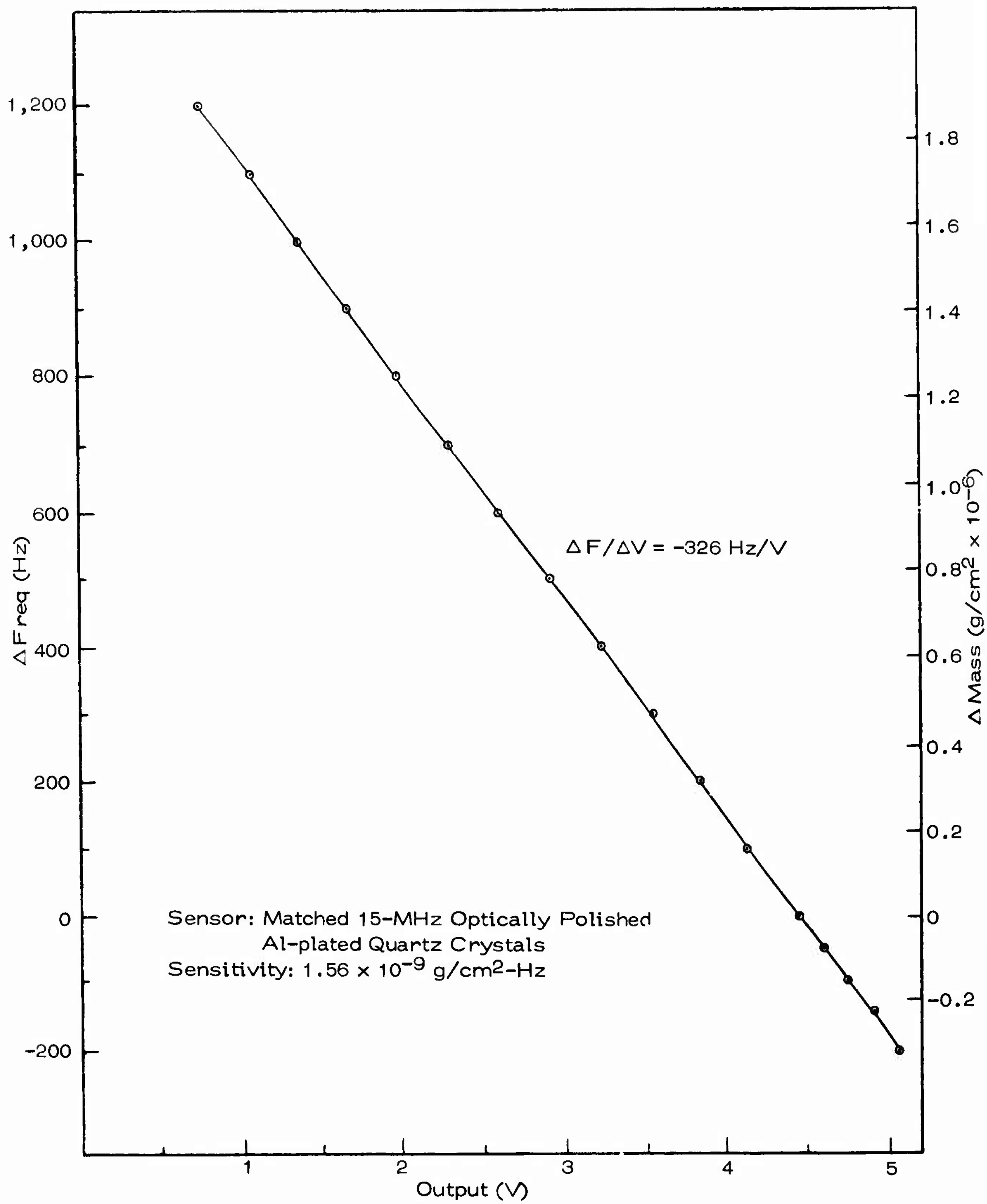


Figure 32 TQCM Head H-1 High-Sensitivity Analog Mass Calibration

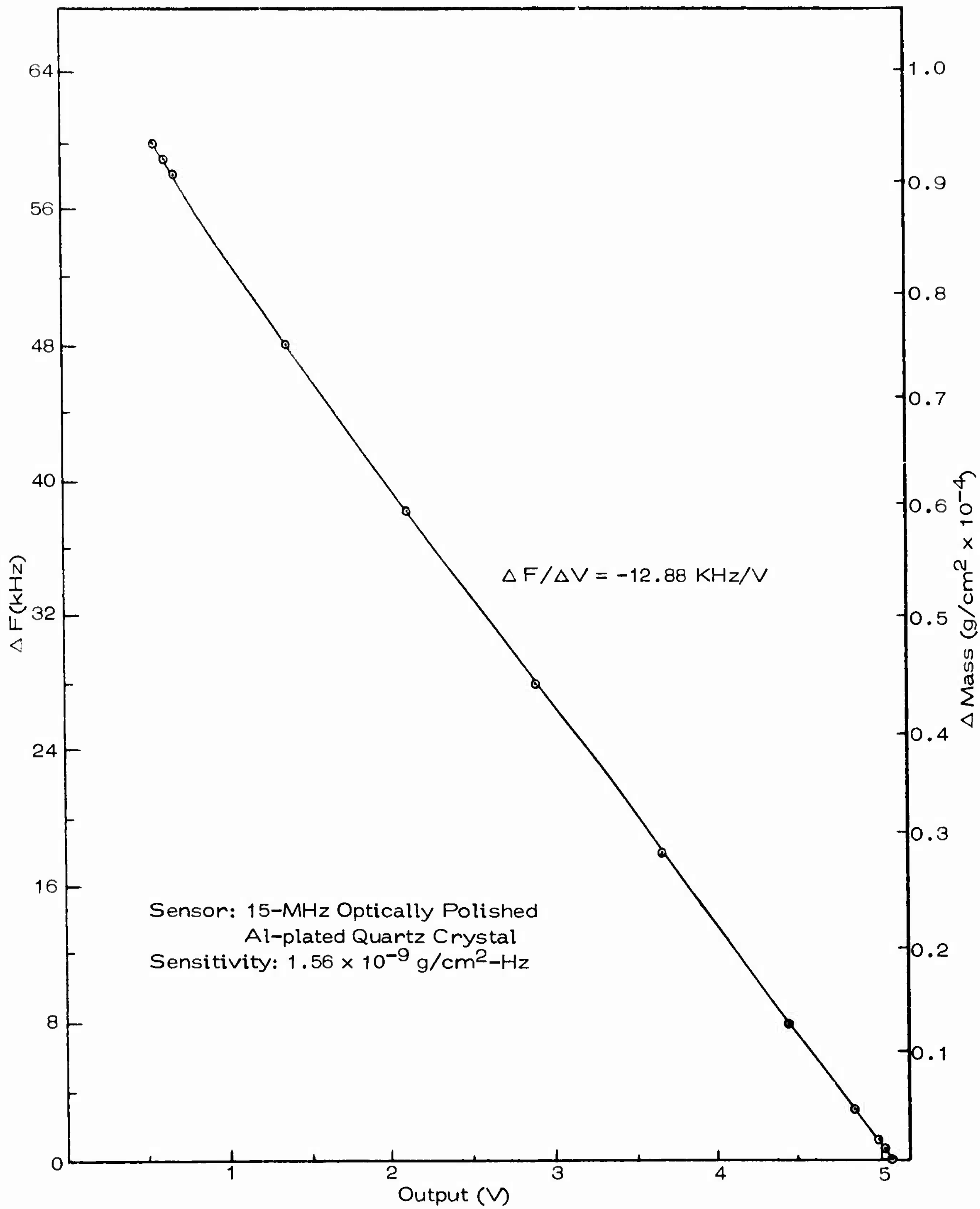


Figure 33 TQCM Head H-1 Los-Sensitivity Analog Mass Calibration

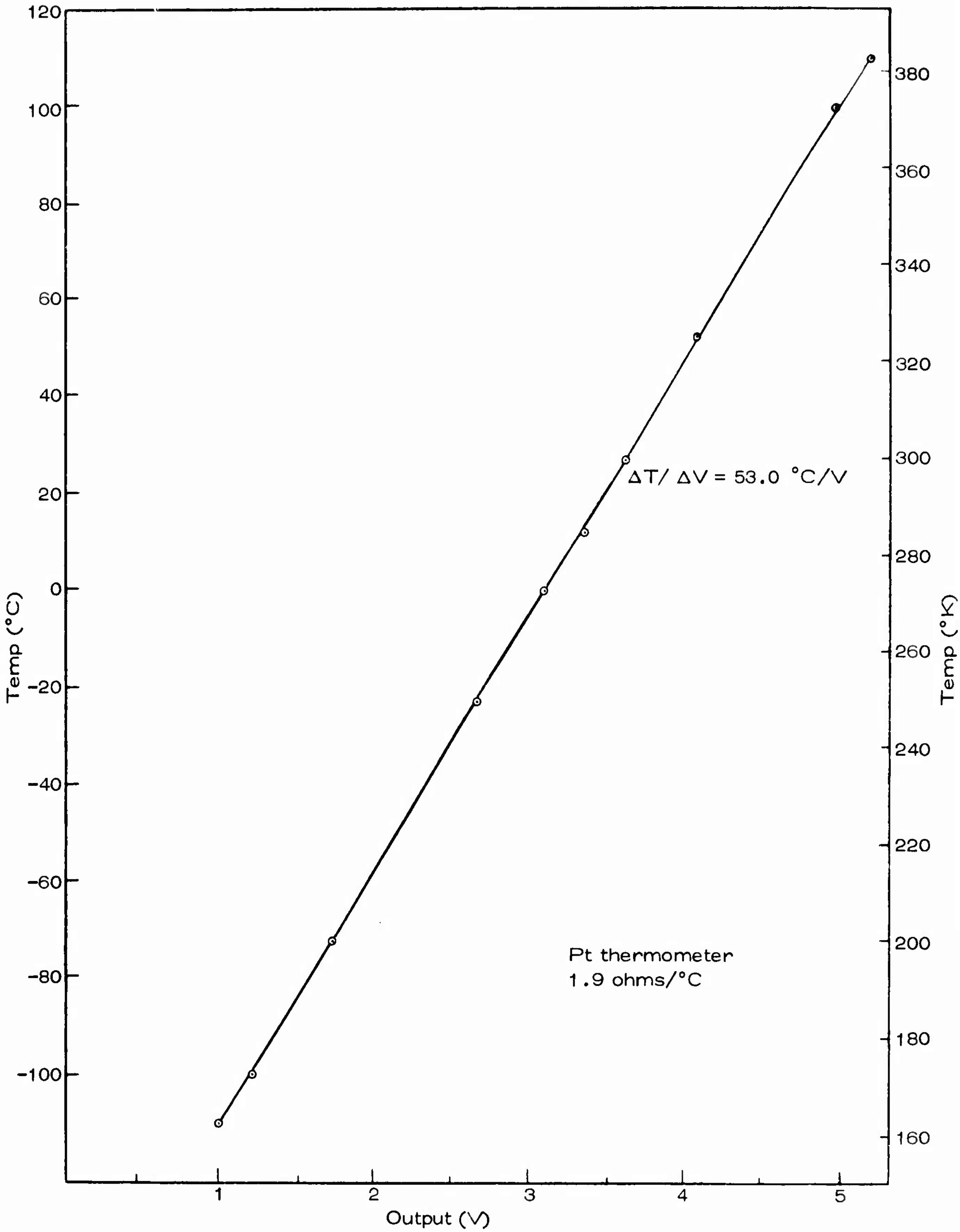


Figure 34 TQCM Head H-1 Temp Calibration

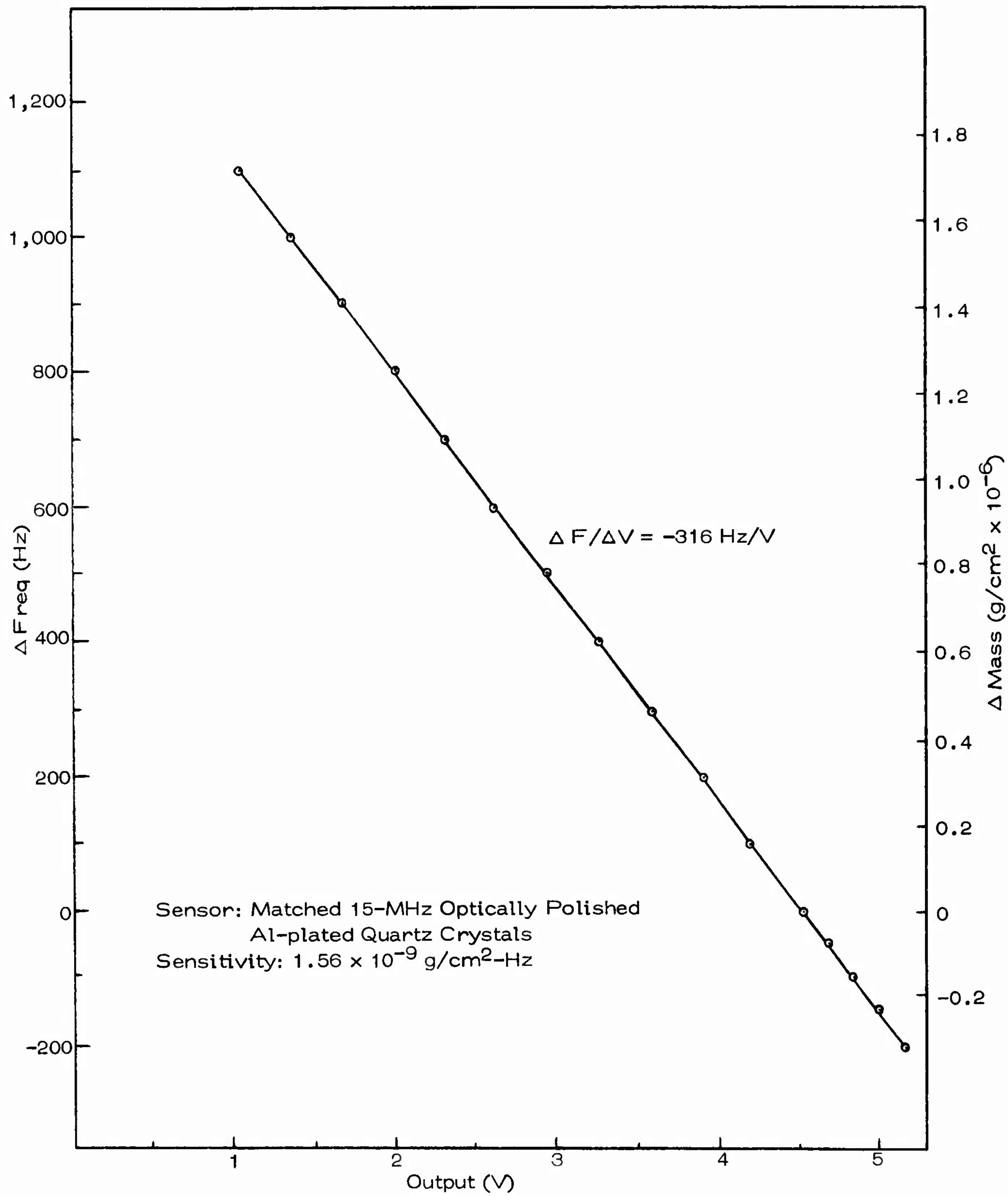


Figure 35 TQCM Head H-2 High-Sensitivity Analog Mass Calibration

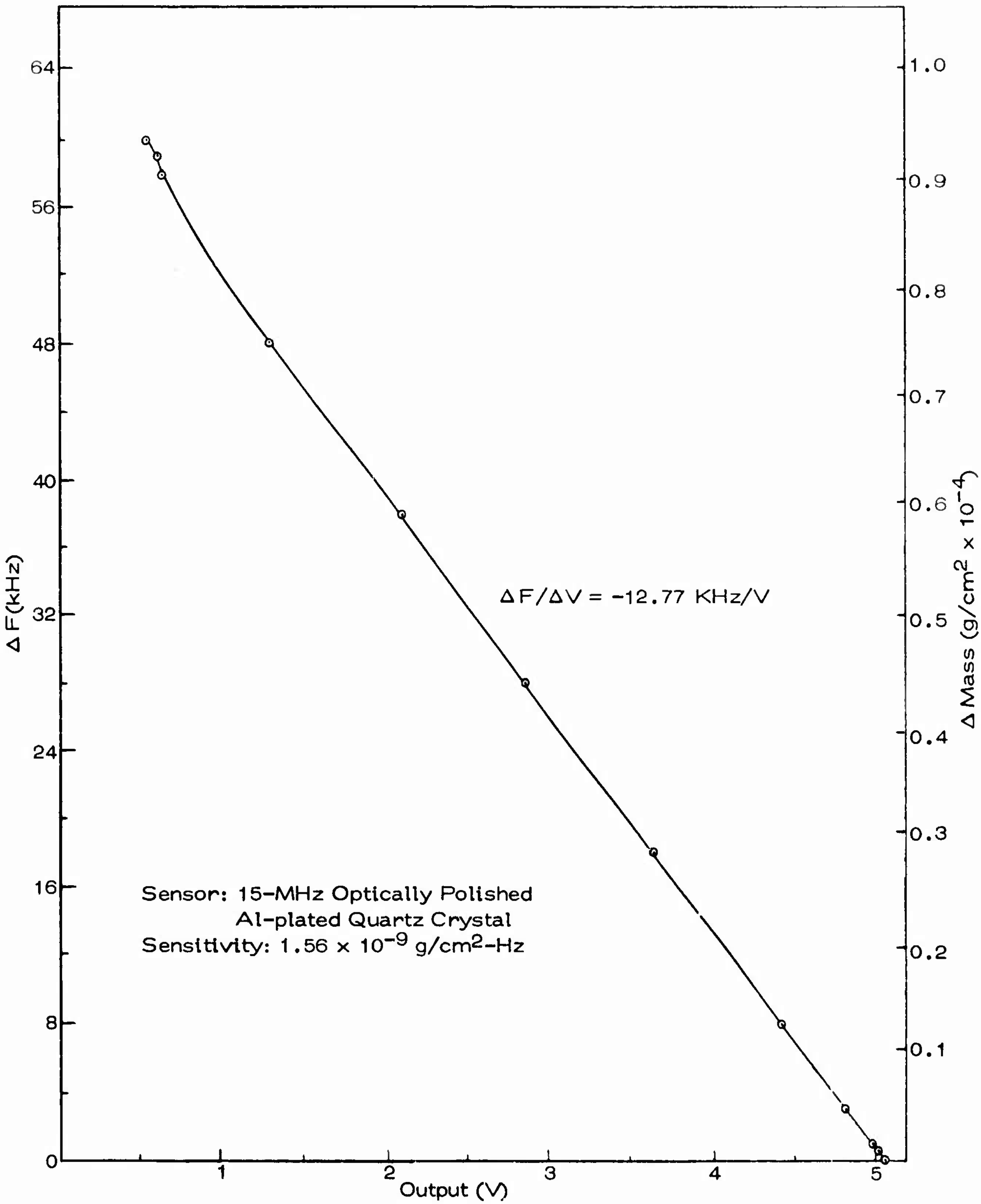


Figure 36 TQCM Head H-2 Low-Sensitivity Analog Mass Calibration

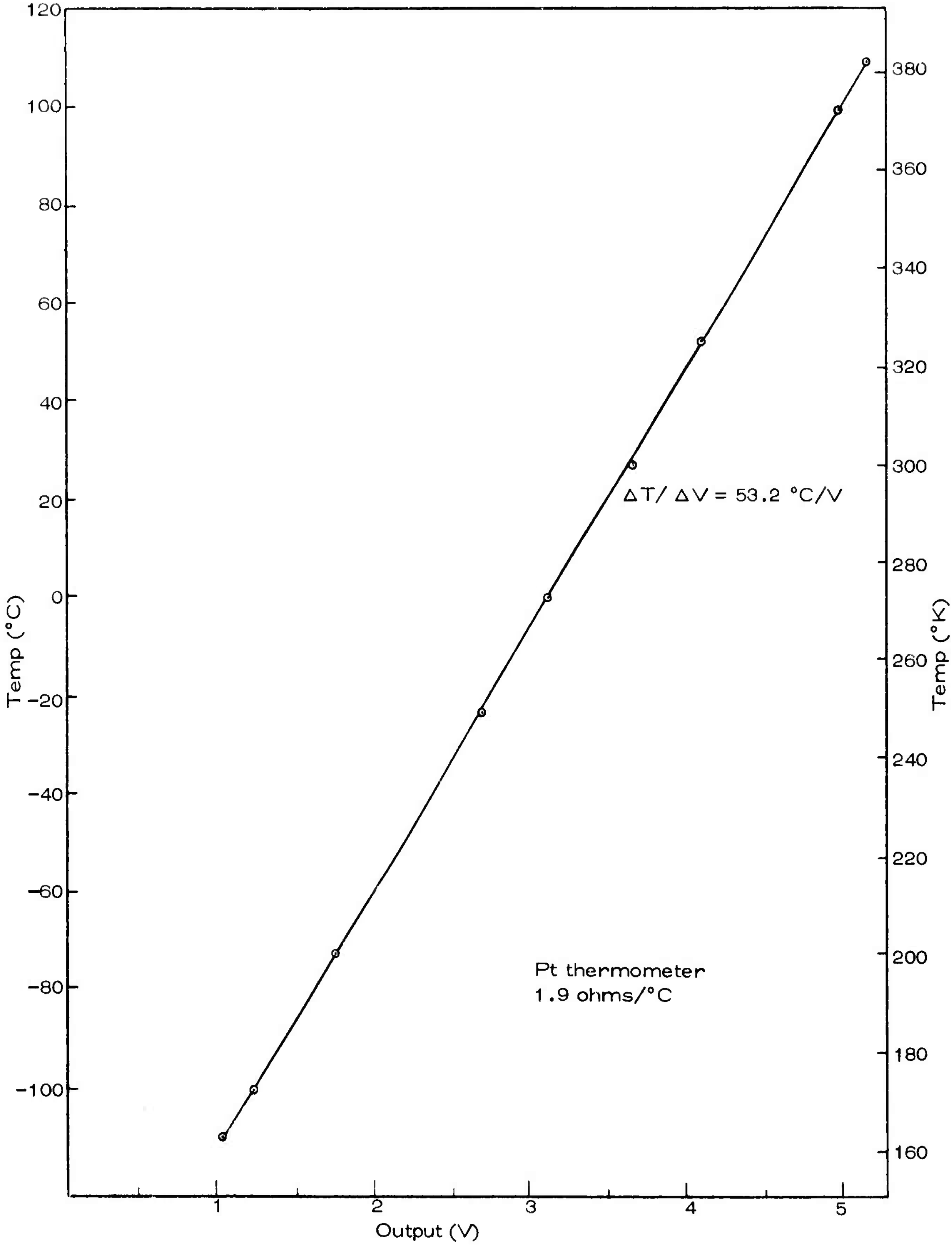


Figure 37 TQCM Head H-2 Temp Calibration

too small to plot. If these variations are to be observed, tabulated data must be used.

6.0 Command Logic

The TQCM System command logic is shown in Table 15.

When the TQCM is commanded to free run, the decoder relay (Figure 28) places 100.8 ohms (R_8) into the temperature control circuit. The nulling temperature for this resistance is −164.6°C or slightly less than the minimum calculated TQCM operating temperature. The reason this resistance value was chosen was to minimize power dissipation during free run but provide a null temperature commensurate to the minimum TQCM operating temperature.

Table 15 TQCM System Serial Command Logic

Serial Bits					Temperature Command
1−18	19	20	21	22	
X	0	0	0	0	Free Run (min temp)
X	1	0	0	0	−60°C
X	0	1	0	0	−30°C
X	1	1	0	0	0°C
X	0	0	1	1	+30°C
X	1	0	1	0	+100°C

REFERENCES

1. McKeown, D., Sonnenschein, G. and Fox, M.G., Cryogenic Quartz Crystal Microbalance, Final Report, FAR-D-001-76, Faraday Laboratories Inc., Prepared for NASA, MSFC, Jan. (1976).

2. McKeown, D., Sonnenschein, G. and Fox, M.G., "CQCM", 8th Space Simulation Conference, NASA SP-379, p. 343, Nov. (1975).

APPENDIX

TQCM SYSTEM

MECHANICAL DESIGN

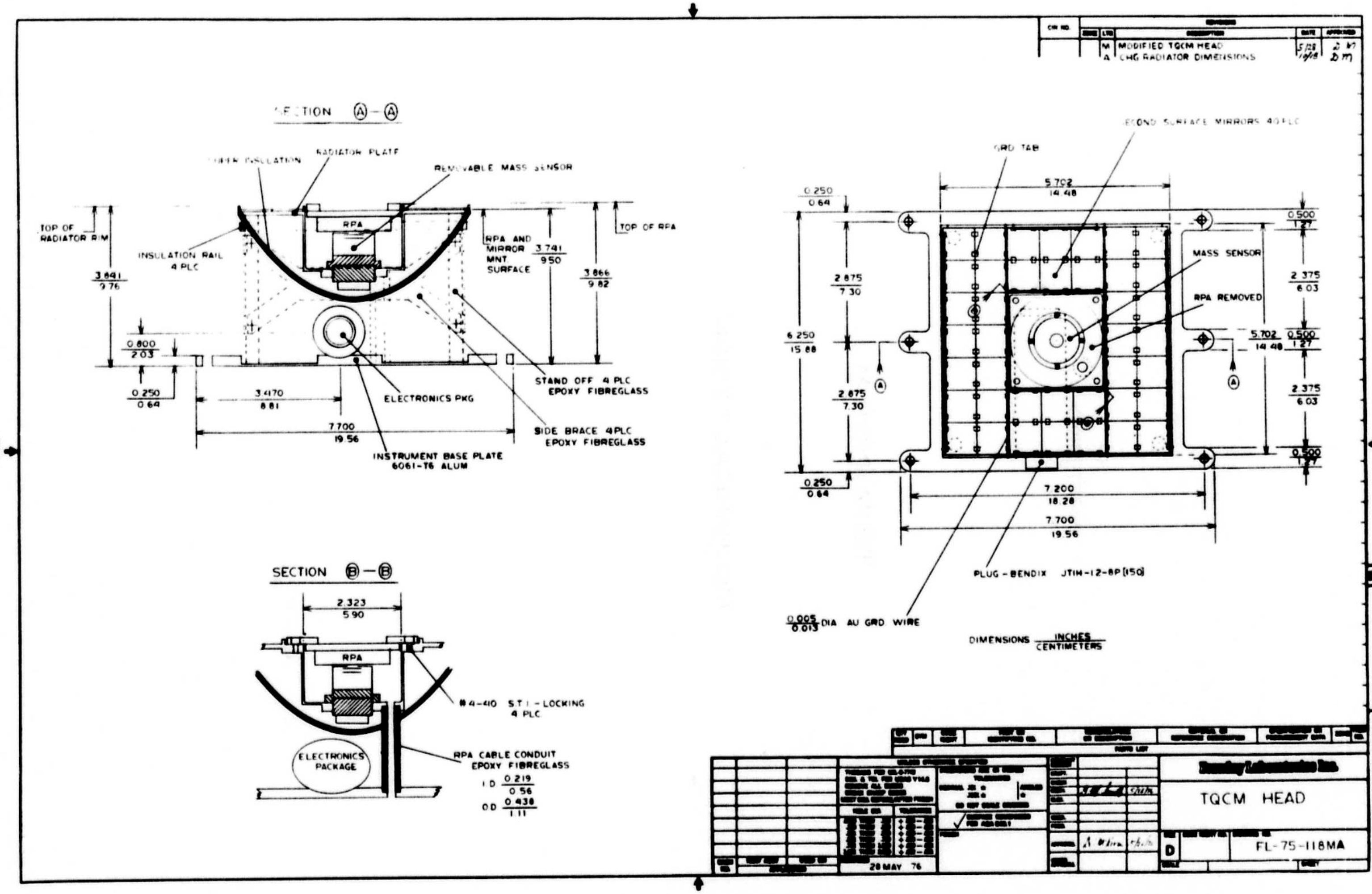
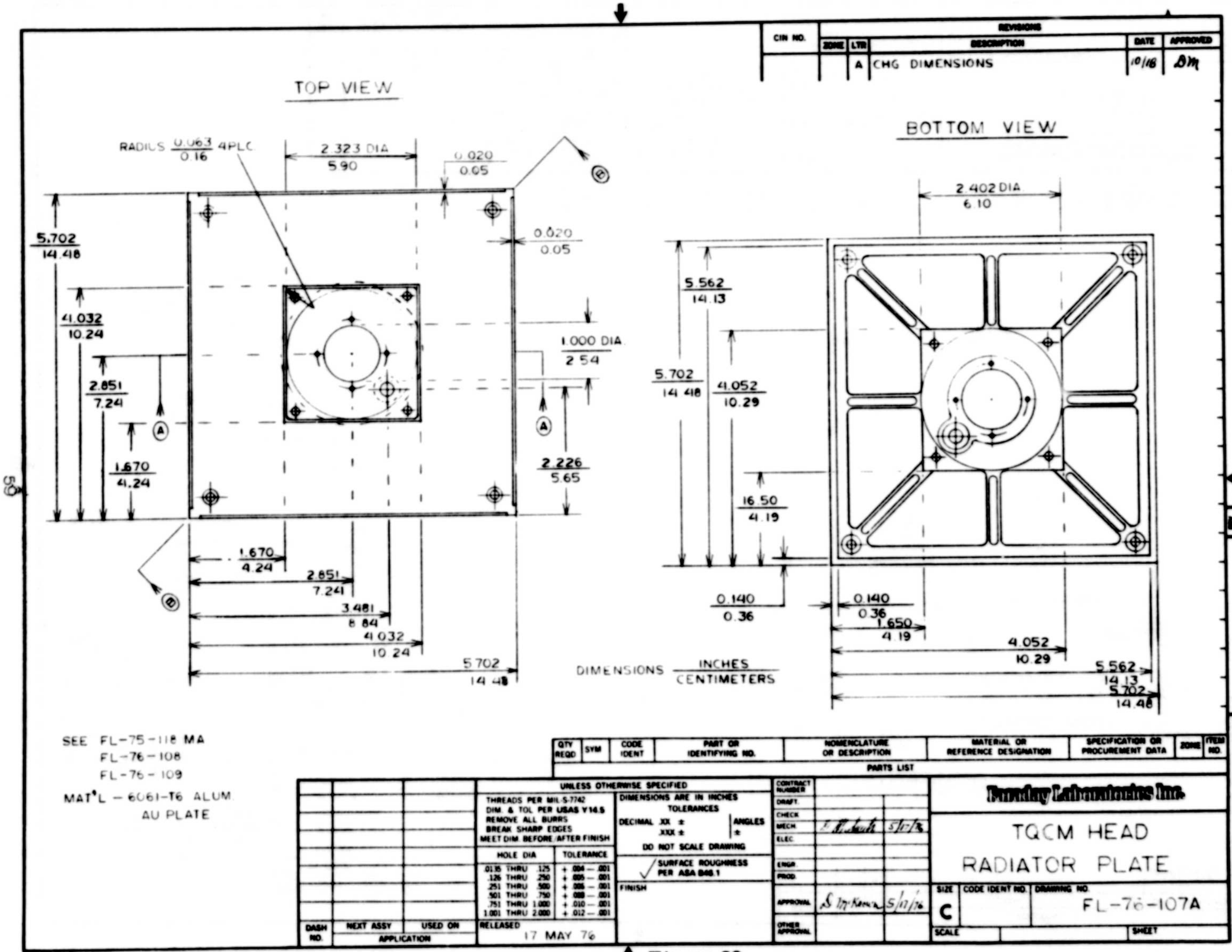

MODIFIED TQCM HEAD
CHG RADIATOR DIMENSIONS
SECTION A-A
RADIATOR PLATE
REMOVABLE MASS SENSOR
TOP OF RADIATOR RIM
INSULATION RAIL 4 PLC
RPA
RPA AND MIRROR MNT SURFACE
TOP OF RPA
ELECTRONICS PKG
STAND OFF 4 PLC EPOXY FIBREGLASS
SIDE BRACE 4PLC EPOXY FIBREGLASS
INSTRUMENT BASE PLATE 6061-T6 ALUM
SECTION B-B
#4-40 S.T.I.-LOCKING 4 PLC
RPA CABLE CONDUIT EPOXY FIBREGLASS
ELECTRONICS PACKAGE
GRD TAB
MASS SENSOR
RPA REMOVED
PLUG-BENDIX JTIH-12-8P(150)
DIA AU GRD WIRE
DIMENSIONS INCHES/CENTIMETERS
TQCM HEAD
FL-75-118MA
28 MAY 76

Figure 38



TOP VIEW
BOTTOM VIEW
RADIUS 0.063/0.16 4PLC
2.323 DIA / 5.90
2.402 DIA / 6.10
1.000 DIA / 2.54
DIMENSIONS INCHES / CENTIMETERS
SEE FL-75-118 MA
FL-76-108
FL-76-109
MAT'L – 6061-T6 ALUM
AU PLATE
REVISIONS
A CHG DIMENSIONS 10/18 BM
PARTS LIST
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM BEFORE/AFTER FINISH
DIMENSIONS ARE IN INCHES
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
RELEASED 17 MAY 76
Faraday Laboratories Inc.
TQCM HEAD
RADIATOR PLATE
C
FL-76-107A

Figure 39

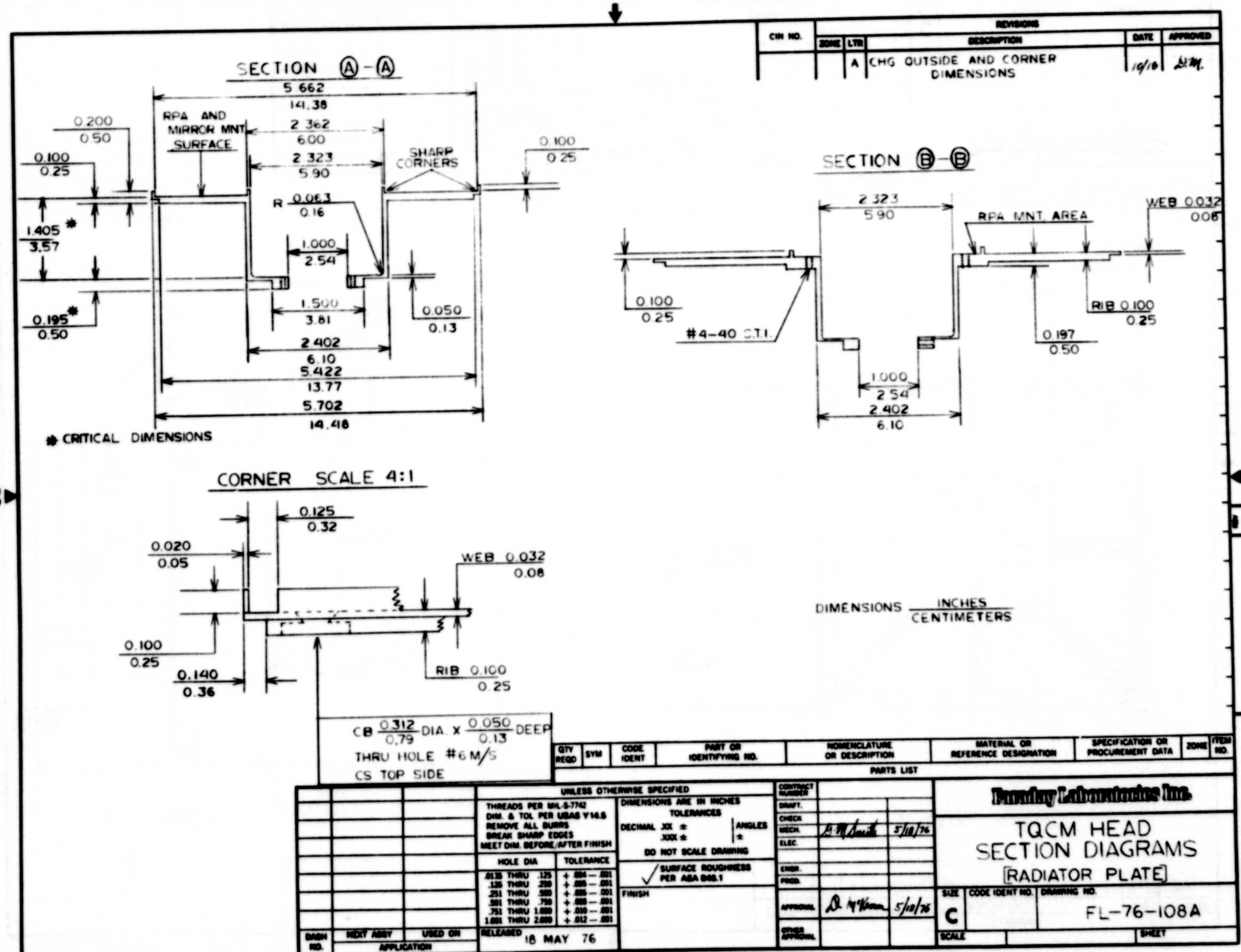

SECTION A-A
RPA AND MIRROR MNT SURFACE
SHARP CORNERS
* CRITICAL DIMENSIONS
CORNER SCALE 4:1
WEB 0.032 / 0.08
RIB 0.100 / 0.25
CB 0.312/0.79 DIA. X 0.050/0.13 DEEP
THRU HOLE #6 M/S
CS TOP SIDE
SECTION B-B
RPA MNT. AREA
#4-40 C.T.I.
DIMENSIONS INCHES / CENTIMETERS
REVISIONS
A CHG OUTSIDE AND CORNER DIMENSIONS
PARTS LIST
UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING
RELEASED 18 MAY 76
Faraday Laboratories Inc.
TQCM HEAD
SECTION DIAGRAMS
[RADIATOR PLATE]
C
FL-76-108A

Figure 40

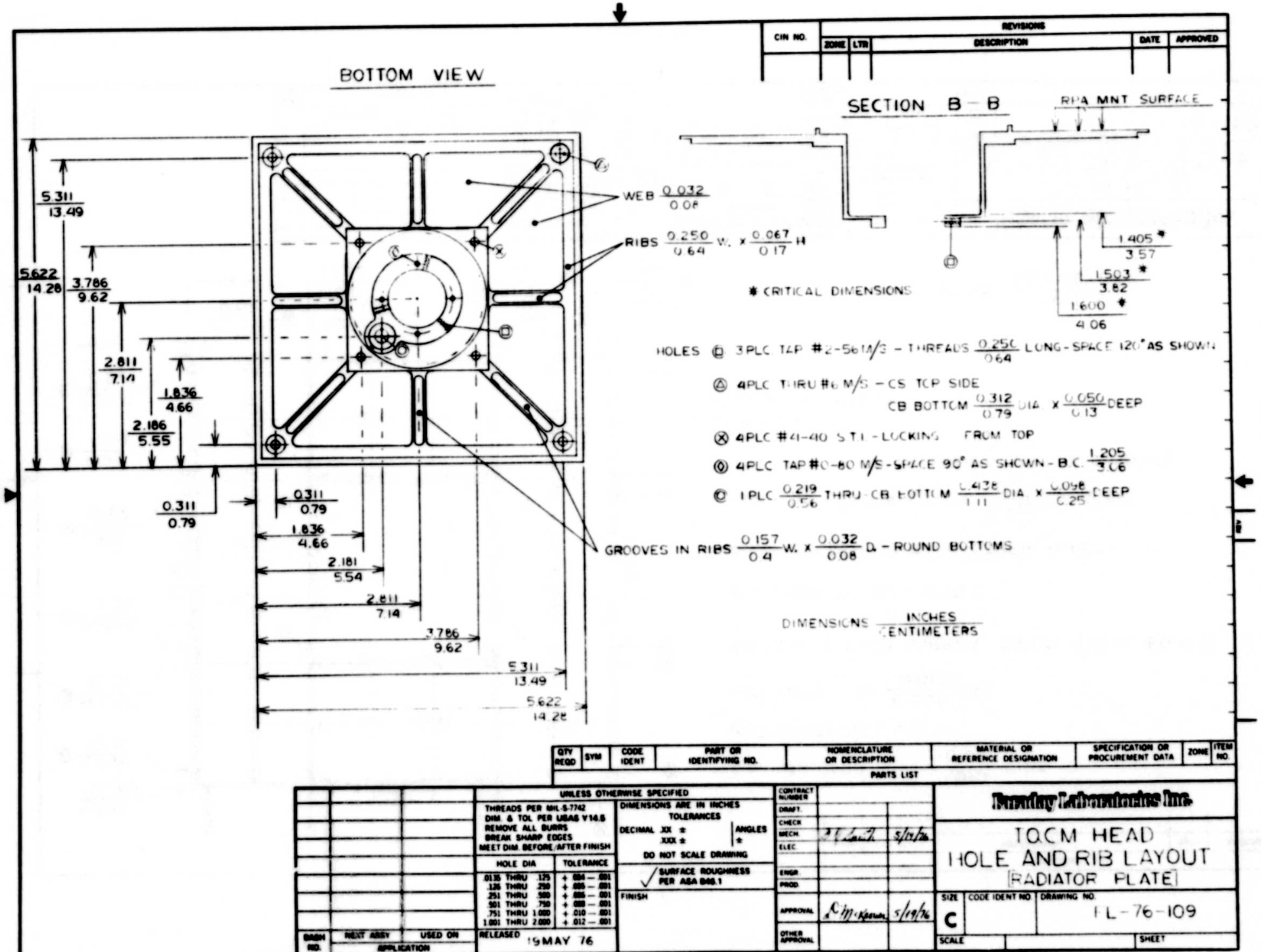

BOTTOM VIEW
SECTION B - B
RPA MNT SURFACE
WEB 0.032 / 0.08
RIBS 0.250 / 0.64 W. x 0.067 / 0.17 H
* CRITICAL DIMENSIONS
1.405 * / 3.57
1.503 * / 3.82
1.600 * / 4.06
HOLES 3PLC TAP #2-56 M/S - THREADS 0.250 / 0.64 LONG - SPACE 120° AS SHOWN
4PLC THRU #6 M/S - CS TOP SIDE
CB BOTTOM 0.312 / 0.79 DIA. x 0.050 / 0.13 DEEP
4PLC #4-40 S.T.I. - LOCKING FROM TOP
4PLC TAP #0-80 M/S - SPACE 90° AS SHOWN - B.C. 1.205 / 3.06
1PLC 0.219 / 0.56 THRU - CB BOTTOM 0.438 / 1.11 DIA. x 0.098 / 0.25 DEEP
GROOVES IN RIBS 0.157 / 0.4 W. x 0.032 / 0.08 D. - ROUND BOTTOMS
DIMENSIONS INCHES / CENTIMETERS
5.311 / 13.49
5.622 / 14.28
3.786 / 9.62
2.811 / 7.14
1.836 / 4.66
2.186 / 5.55
0.311 / 0.79
2.181 / 5.54
REVISIONS
CIN NO.
ZONE
LTR
DESCRIPTION
DATE
APPROVED
QTY REQD
SYM
CODE IDENT
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR REFERENCE DESIGNATION
SPECIFICATION OR PROCUREMENT DATA
ZONE
ITEM NO.
PARTS LIST
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL. PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM. BEFORE/AFTER FINISH
HOLE DIA
TOLERANCE
.0135 THRU .125 + .004 — .001
.126 THRU .250 + .005 — .001
.251 THRU .500 + .005 — .001
.501 THRU .750 + .008 — .001
.751 THRU 1.000 + .010 — .001
1.001 THRU 2.000 + .012 — .001
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL .XX ±
.XXX ±
ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
FINISH
DASH NO.
NEXT ASSY
USED ON
APPLICATION
RELEASED 19 MAY 76
CONTRACT NUMBER
DRAFT.
CHECK
MECH.
ELEC.
ENGR.
PROD.
APPROVAL
OTHER APPROVAL
5/19/76
Faraday Laboratories Inc.
IQCM HEAD
HOLE AND RIB LAYOUT
[RADIATOR PLATE]
SIZE C
CODE IDENT NO.
DRAWING NO. FL-76-109
SCALE
SHEET

Figure 41

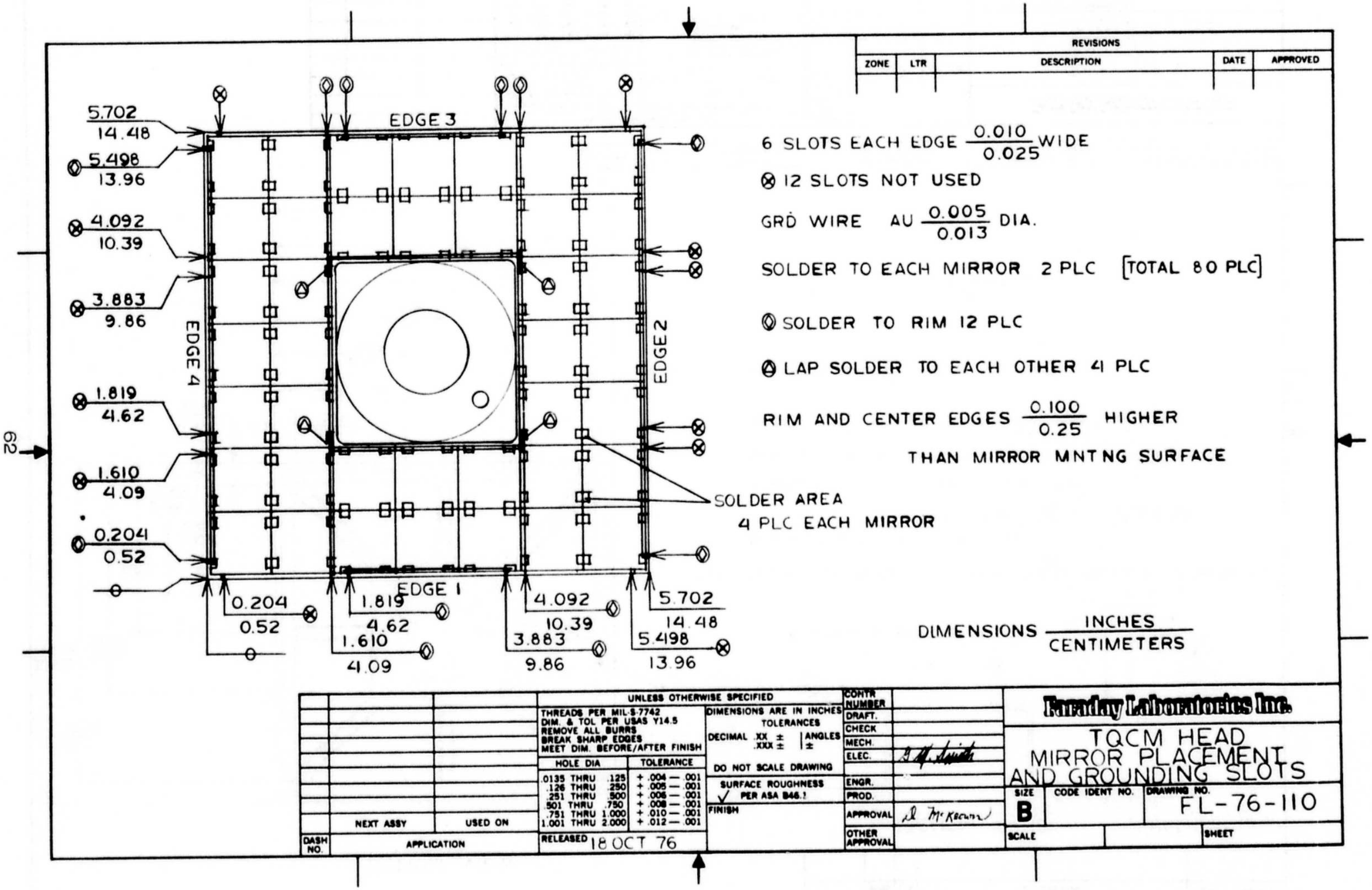

REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
EDGE 3
EDGE 4
EDGE 2
EDGE 1
5.702 / 14.48
5.498 / 13.96
4.092 / 10.39
3.883 / 9.86
1.819 / 4.62
1.610 / 4.09
0.204 / 0.52
6 SLOTS EACH EDGE 0.010 / 0.025 WIDE
12 SLOTS NOT USED
GRD WIRE AU 0.005 / 0.013 DIA.
SOLDER TO EACH MIRROR 2 PLC [TOTAL 80 PLC]
SOLDER TO RIM 12 PLC
LAP SOLDER TO EACH OTHER 4 PLC
RIM AND CENTER EDGES 0.100 / 0.25 HIGHER
THAN MIRROR MNTNG SURFACE
SOLDER AREA
4 PLC EACH MIRROR
DIMENSIONS INCHES / CENTIMETERS
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM. BEFORE/AFTER FINISH
HOLE DIA
TOLERANCE
.0135 THRU .125 + .004 — .001
.126 THRU .250 + .005 — .001
.251 THRU .500 + .006 — .001
.501 THRU .750 + .008 — .001
.751 THRU 1.000 + .010 — .001
1.001 THRU 2.000 + .012 — .001
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL .XX ± .XXX ±
ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS
PER ASA B46.1
FINISH
CONTR NUMBER
DRAFT.
CHECK
MECH.
ELEC.
ENGR.
PROD.
APPROVAL
OTHER APPROVAL
NEXT ASSY
USED ON
DASH NO.
APPLICATION
RELEASED 18 OCT 76
Faraday Laboratories Inc.
TQCM HEAD
MIRROR PLACEMENT
AND GROUNDING SLOTS
SIZE B
CODE IDENT NO.
DRAWING NO.
FL-76-110
SCALE
SHEET

Figure 42

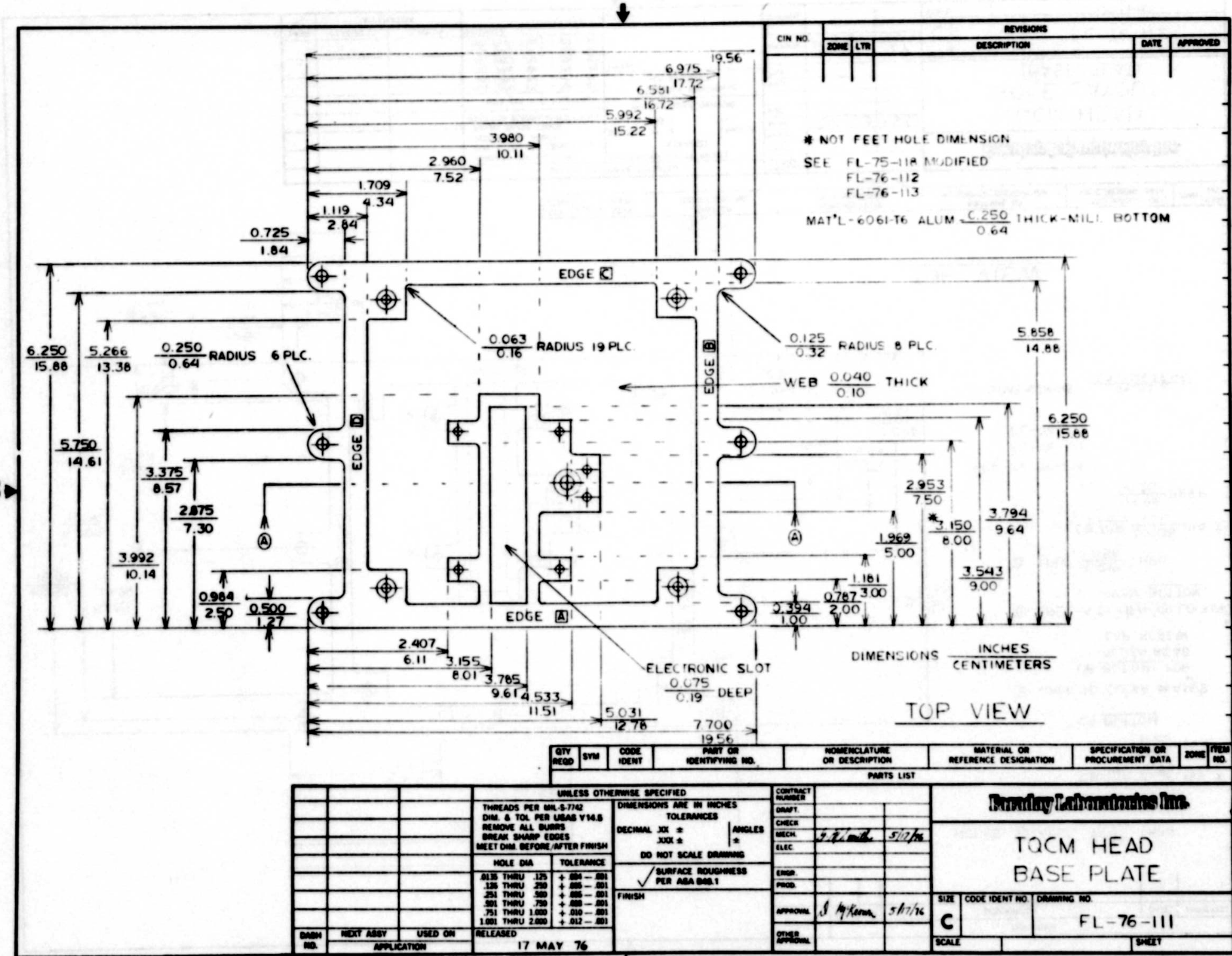

* NOT FEET HOLE DIMENSION
SEE FL-75-118 MODIFIED
FL-76-112
FL-76-113
MAT'L-6061-T6 ALUM 0.250/0.64 THICK-MILL BOTTOM
0.063/0.16 RADIUS 19 PLC.
0.125/0.32 RADIUS 8 PLC.
0.250/0.64 RADIUS 6 PLC.
WEB 0.040/0.10 THICK
ELECTRONIC SLOT 0.075/0.19 DEEP
EDGE A
EDGE B
EDGE C
EDGE D
DIMENSIONS INCHES/CENTIMETERS
TOP VIEW
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
DO NOT SCALE DRAWING
RELEASED 17 MAY 76
Faraday Laboratories Inc.
TQCM HEAD
BASE PLATE
SIZE C
FL-76-111

Figure 43

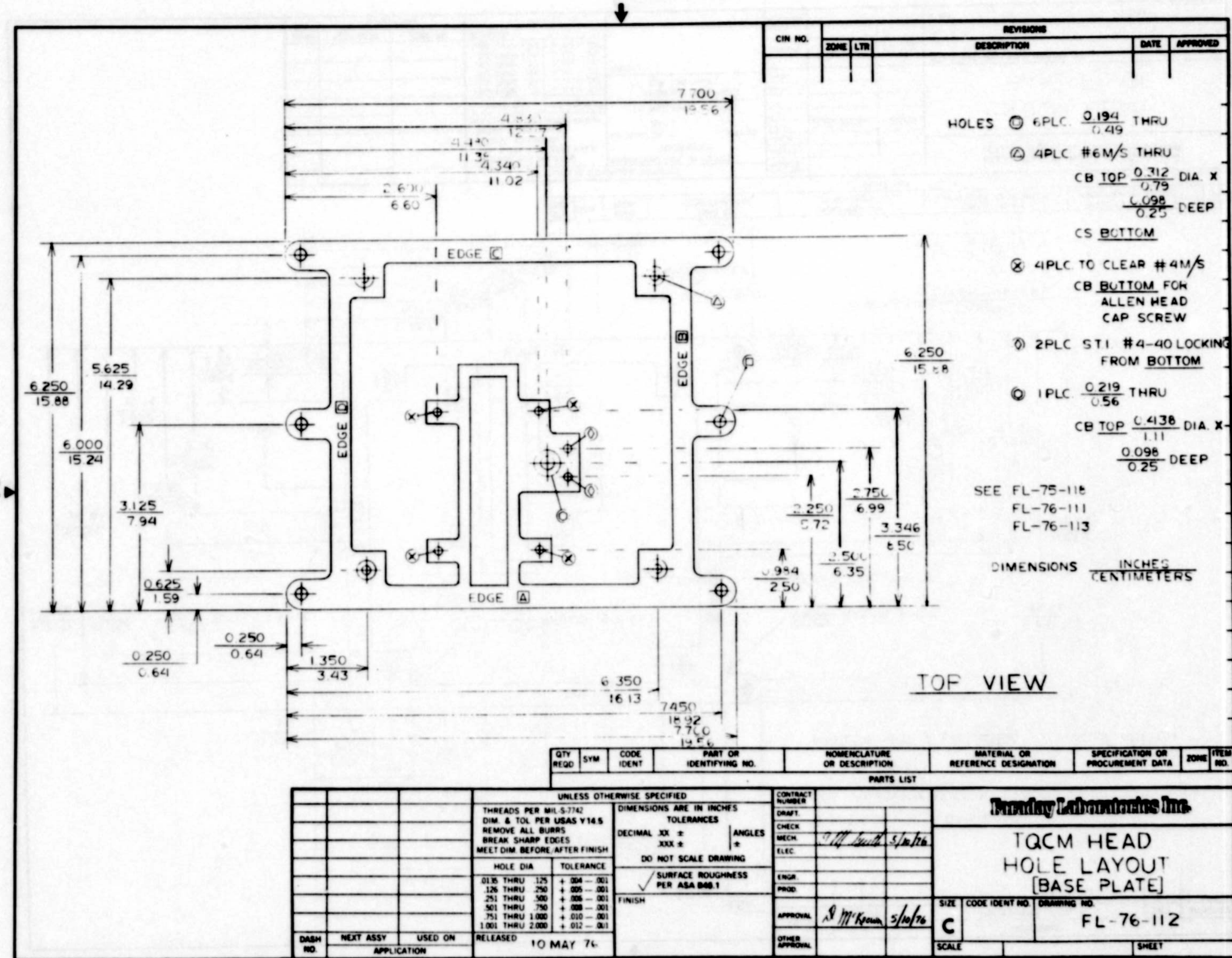
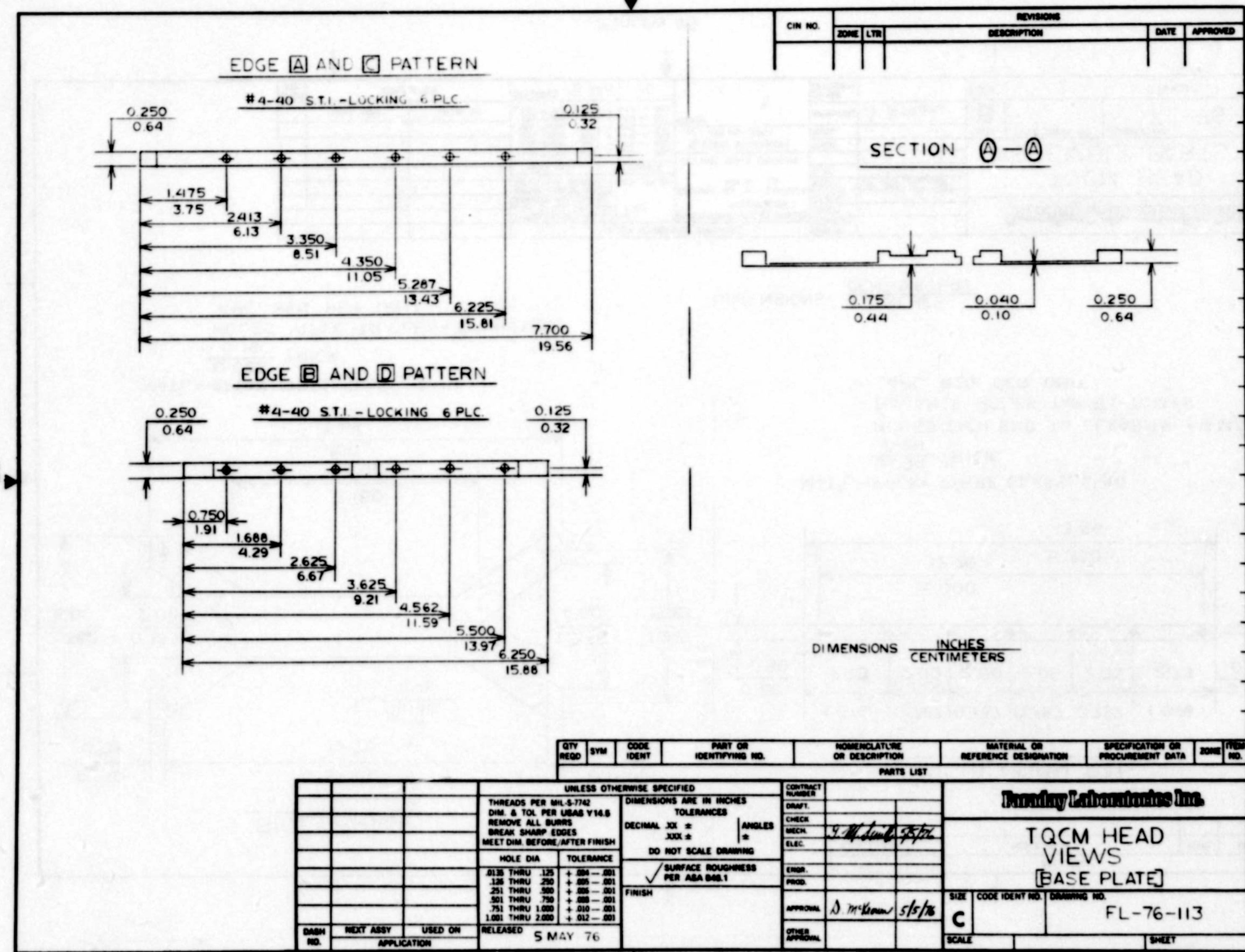

HOLES 6PLC. 0.194/0.49 THRU
4PLC #6M/S THRU
CB TOP 0.312/0.79 DIA. X 0.098/0.25 DEEP
CS BOTTOM
4PLC. TO CLEAR #4M/S
CB BOTTOM FOR ALLEN HEAD CAP SCREW
2PLC STI. #4-40 LOCKING FROM BOTTOM
1PLC. 0.219/0.56 THRU
CB TOP 0.438/1.11 DIA. X 0.098/0.25 DEEP
SEE FL-75-118
FL-76-111
FL-76-113
DIMENSIONS INCHES/CENTIMETERS
TOP VIEW
EDGE A
EDGE B
EDGE C
EDGE D
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM. BEFORE/AFTER FINISH
DIMENSIONS ARE IN INCHES
TOLERANCES
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
RELEASED 10 MAY 76
PARTS LIST
Faraday Laboratories Inc.
TQCM HEAD
HOLE LAYOUT
[BASE PLATE]
SIZE C
FL-76-112

Figure 44



EDGE A AND C PATTERN
#4-40 S.T.I.-LOCKING 6 PLC.
0.250 / 0.64
0.125 / 0.32
1.475 / 3.75
2.413 / 6.13
3.350 / 8.51
4.350 / 11.05
5.287 / 13.43
6.225 / 15.81
7.700 / 19.56
EDGE B AND D PATTERN
#4-40 S.T.I.-LOCKING 6 PLC.
0.250 / 0.64
0.125 / 0.32
0.750 / 1.91
1.688 / 4.29
2.625 / 6.67
3.625 / 9.21
4.562 / 11.59
5.500 / 13.97
6.250 / 15.88
SECTION A—A
0.175 / 0.44
0.040 / 0.10
0.250 / 0.64
DIMENSIONS INCHES / CENTIMETERS
Faraday Laboratories Inc.
TQCM HEAD
VIEWS
[BASE PLATE]
FL-76-113
RELEASED 5 MAY 76

Figure 45

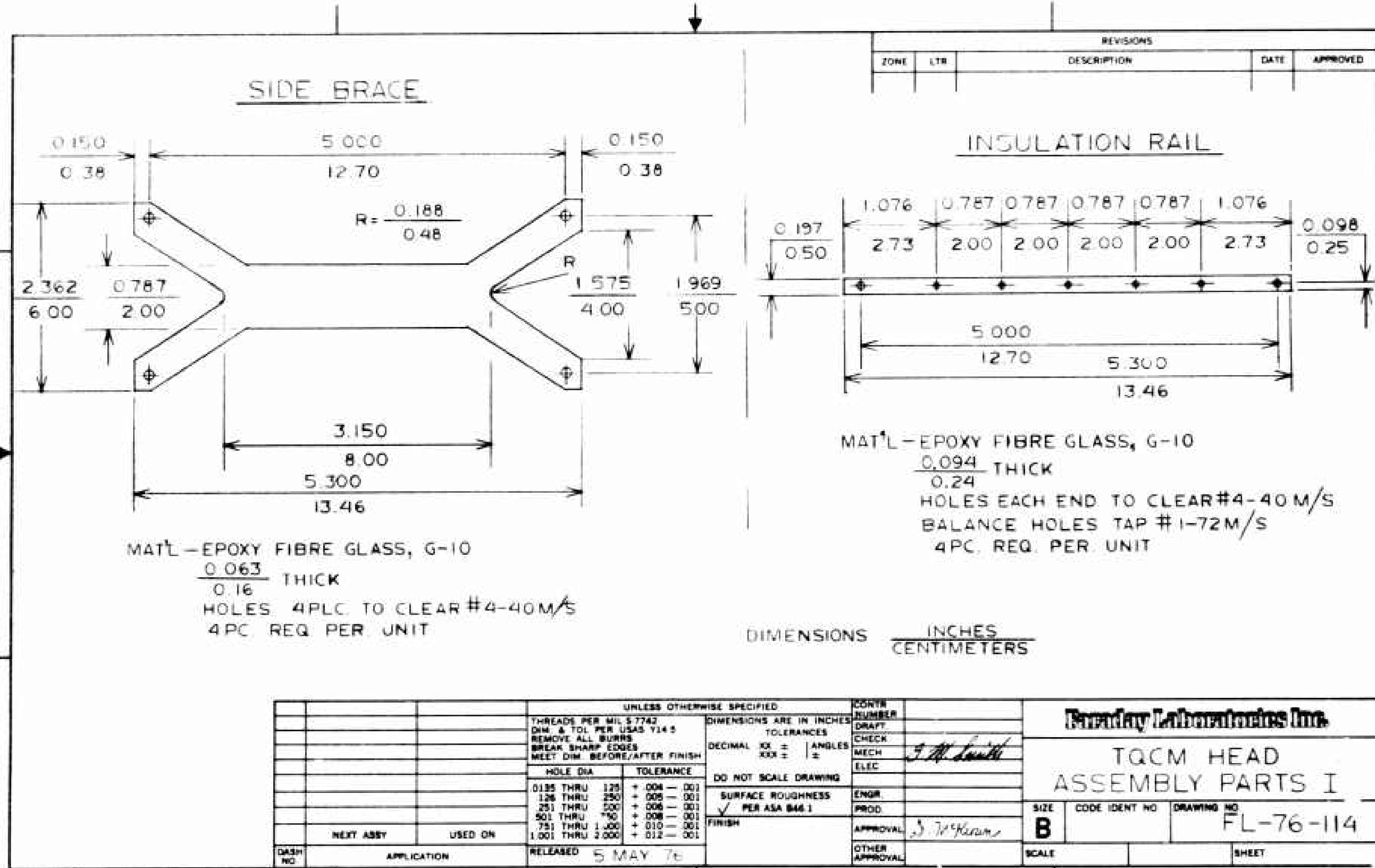
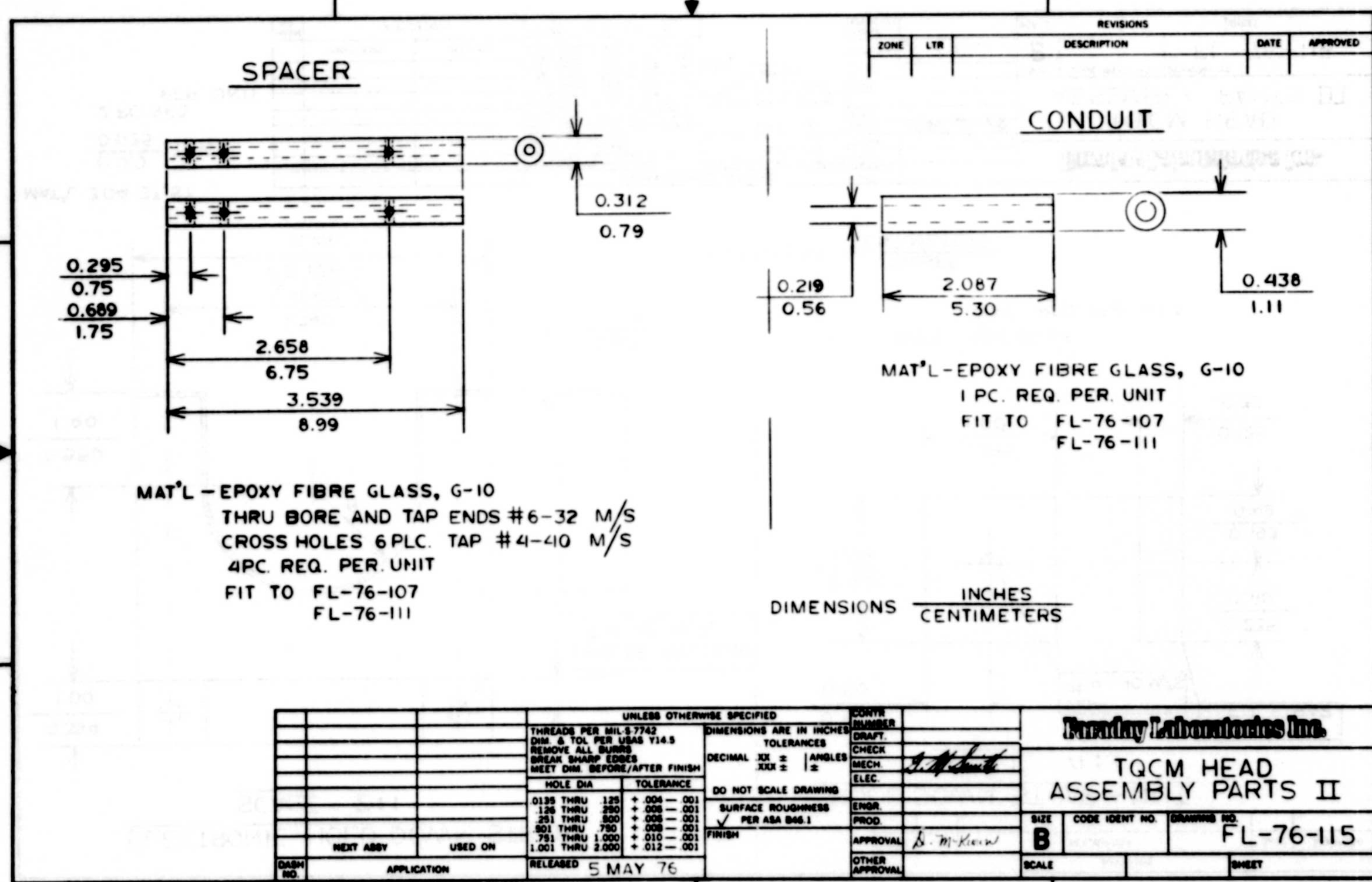
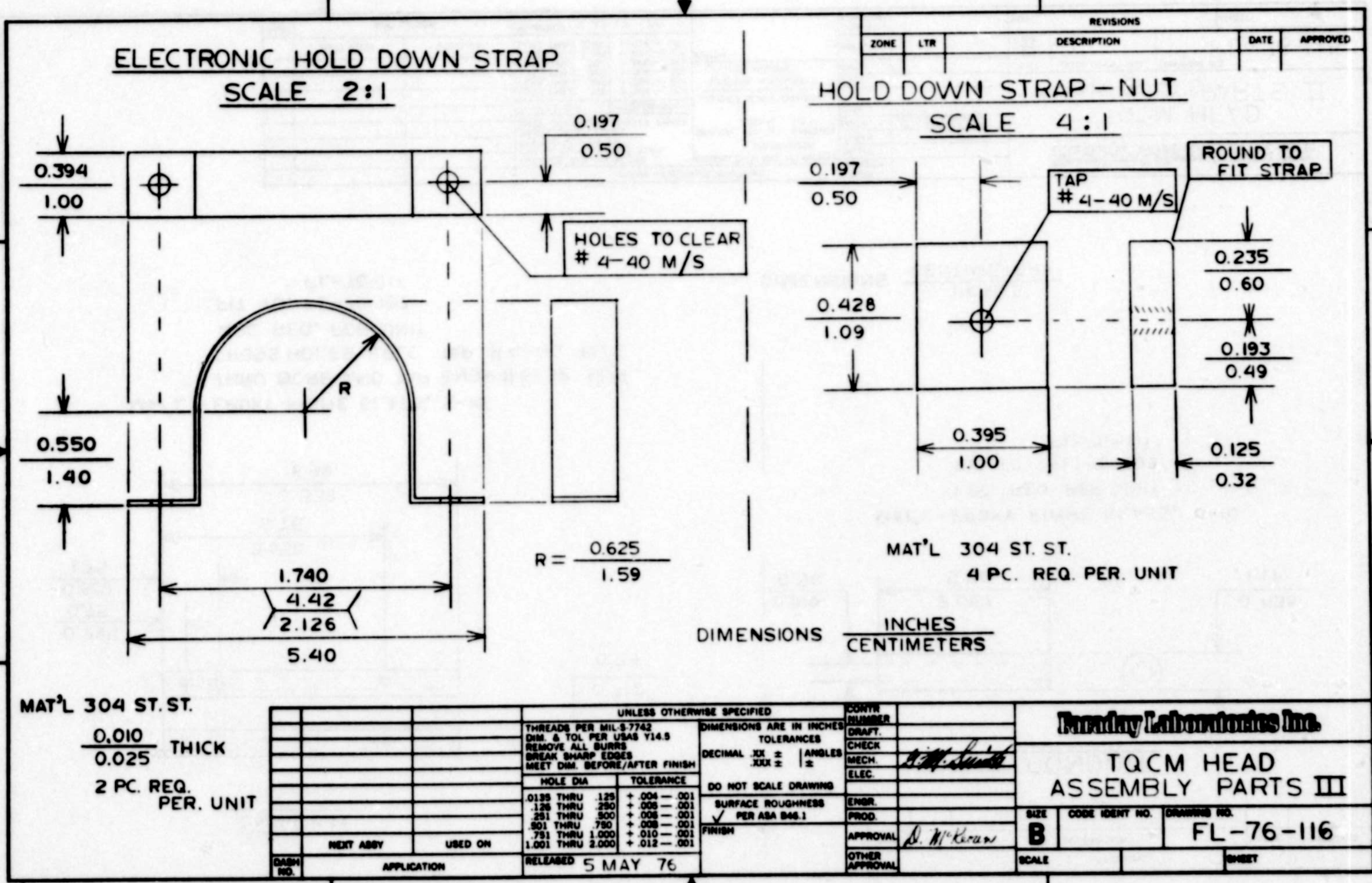

SIDE BRACE
0.150 / 0.38
5.000 / 12.70
R= 0.188 / 0.48
R
2.362 / 6.00
0.787 / 2.00
1.575 / 4.00
1.969 / 5.00
3.150 / 8.00
5.300 / 13.46
MAT'L-EPOXY FIBRE GLASS, G-10
0.063 / 0.16 THICK
HOLES 4PLC TO CLEAR #4-40M/S
4PC REQ PER UNIT
INSULATION RAIL
1.076 / 2.73
0.787 / 2.00
0.197 / 0.50
0.098 / 0.25
5.000 / 12.70
5.300 / 13.46
MAT'L-EPOXY FIBRE GLASS, G-10
0.094 / 0.24 THICK
HOLES EACH END TO CLEAR #4-40 M/S
BALANCE HOLES TAP #1-72M/S
4PC. REQ. PER UNIT
DIMENSIONS INCHES / CENTIMETERS
REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM. BEFORE/AFTER FINISH
HOLE DIA TOLERANCE
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL XX ± XXX ± ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
FINISH
NEXT ASSY USED ON
APPLICATION
DASH NO
RELEASED 5 MAY 76
CONTR NUMBER
DRAFT
CHECK
MECH
ELEC
ENGR
PROD
APPROVAL
OTHER APPROVAL
Faraday Laboratories Inc.
TQCM HEAD
ASSEMBLY PARTS I
SIZE B
CODE IDENT NO
DRAWING NO FL-76-114
SCALE
SHEET

Figure 46



SPACER
0.312
0.79
0.295
0.75
0.689
1.75
2.658
6.75
3.539
8.99
MAT'L – EPOXY FIBRE GLASS, G-10
THRU BORE AND TAP ENDS #6-32 M/S
CROSS HOLES 6 PLC. TAP #4-40 M/S
4PC. REQ. PER. UNIT
FIT TO FL-76-107
FL-76-111
CONDUIT
0.219
0.56
2.087
5.30
0.438
1.11
MAT'L - EPOXY FIBRE GLASS, G-10
1 PC. REQ. PER. UNIT
FIT TO FL-76-107
FL-76-111
DIMENSIONS INCHES / CENTIMETERS
REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM. BEFORE/AFTER FINISH
HOLE DIA
TOLERANCE
.0135 THRU .125 + .004 — .001
.126 THRU .250 + .005 — .001
.251 THRU .500 + .006 — .001
.501 THRU .750 + .008 — .001
.751 THRU 1.000 + .010 — .001
1.001 THRU 2.000 + .012 — .001
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL .XX ± .XXX ± ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
FINISH
RELEASED 5 MAY 76
NEXT ASSY
USED ON
DASH NO.
APPLICATION
CONTR NUMBER
DRAFT.
CHECK
MECH.
ELEC.
ENGR.
PROD.
APPROVAL
OTHER APPROVAL
Faraday Laboratories Inc.
TQCM HEAD
ASSEMBLY PARTS II
SIZE B
CODE IDENT NO.
DRAWING NO. FL-76-115
SCALE
SHEET

Figure 47



ELECTRONIC HOLD DOWN STRAP
SCALE 2:1
0.394
1.00
0.197
0.50
HOLES TO CLEAR
4-40 M/S
R
0.550
1.40
1.740
4.42
2.126
5.40
R = 0.625 / 1.59
MAT'L 304 ST. ST.
0.010 / 0.025 THICK
2 PC. REQ.
PER. UNIT
HOLD DOWN STRAP - NUT
SCALE 4:1
ROUND TO
FIT STRAP
TAP
4-40 M/S
0.197
0.50
0.428
1.09
0.235
0.60
0.193
0.49
0.395
1.00
0.125
0.32
MAT'L 304 ST. ST.
4 PC. REQ. PER. UNIT
DIMENSIONS INCHES / CENTIMETERS
REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM. BEFORE/AFTER FINISH
HOLE DIA
TOLERANCE
.0135 THRU .125 + .004 — .001
.126 THRU .250 + .005 — .001
.251 THRU .500 + .006 — .001
.501 THRU .750 + .008 — .001
.751 THRU 1.000 + .010 — .001
1.001 THRU 2.000 + .012 — .001
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL .XX ± .XXX ± ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS
PER ASA B46.1
FINISH
NEXT ASSY
USED ON
DASH NO.
APPLICATION
RELEASED 5 MAY 76
CONTR NUMBER
DRAFT.
CHECK
MECH.
ELEC.
ENGR.
PROD.
APPROVAL
OTHER APPROVAL
Faraday Laboratories Inc.
TQCM HEAD
ASSEMBLY PARTS III
SIZE B
CODE IDENT NO.
DRAWING NO.
FL-76-116
SCALE
SHEET

Figure 48

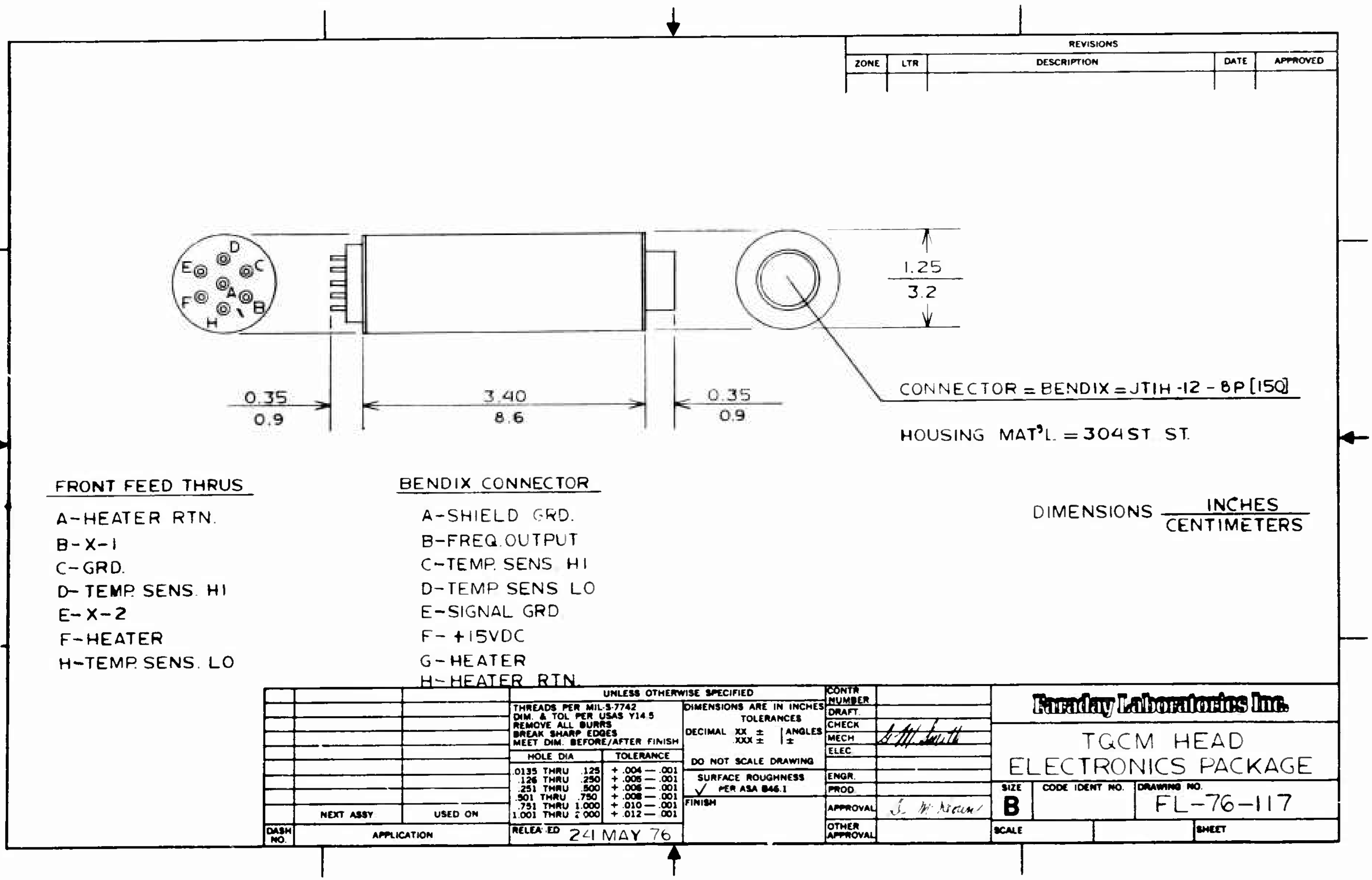

REVISIONS
ZONE LTR DESCRIPTION DATE APPROVED
D C E A B F H
1.25
3.2
0.35
0.9
3.40
8.6
0.35
0.9
CONNECTOR = BENDIX = JTIH-12-8P [150]
HOUSING MAT'L = 304 ST ST.
FRONT FEED THRUS
A-HEATER RTN.
B-X-1
C-GRD.
D-TEMP. SENS. HI
E-X-2
F-HEATER
H-TEMP. SENS. LO
BENDIX CONNECTOR
A-SHIELD GRD.
B-FREQ. OUTPUT
C-TEMP. SENS. HI
D-TEMP SENS LO
E-SIGNAL GRD
F- +15VDC
G-HEATER
H-HEATER RTN.
DIMENSIONS INCHES / CENTIMETERS
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM. BEFORE/AFTER FINISH
HOLE DIA TOLERANCE
.0135 THRU .125 +.004 — .001
.126 THRU .250 +.005 — .001
.251 THRU .500 +.006 — .001
.501 THRU .750 +.008 — .001
.751 THRU 1.000 +.010 — .001
1.001 THRU 2.000 +.012 — .001
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL XX ± XXX ± ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
FINISH
RELEASED 24 MAY 76
NEXT ASSY USED ON
DASH NO. APPLICATION
CONTR NUMBER
DRAFT.
CHECK
MECH
ELEC
ENGR.
PROD.
APPROVAL
OTHER APPROVAL
Faraday Laboratories Inc.
TGCM HEAD
ELECTRONICS PACKAGE
SIZE B
CODE IDENT NO.
DRAWING NO. FL-76-117
SCALE
SHEET

Figure 49

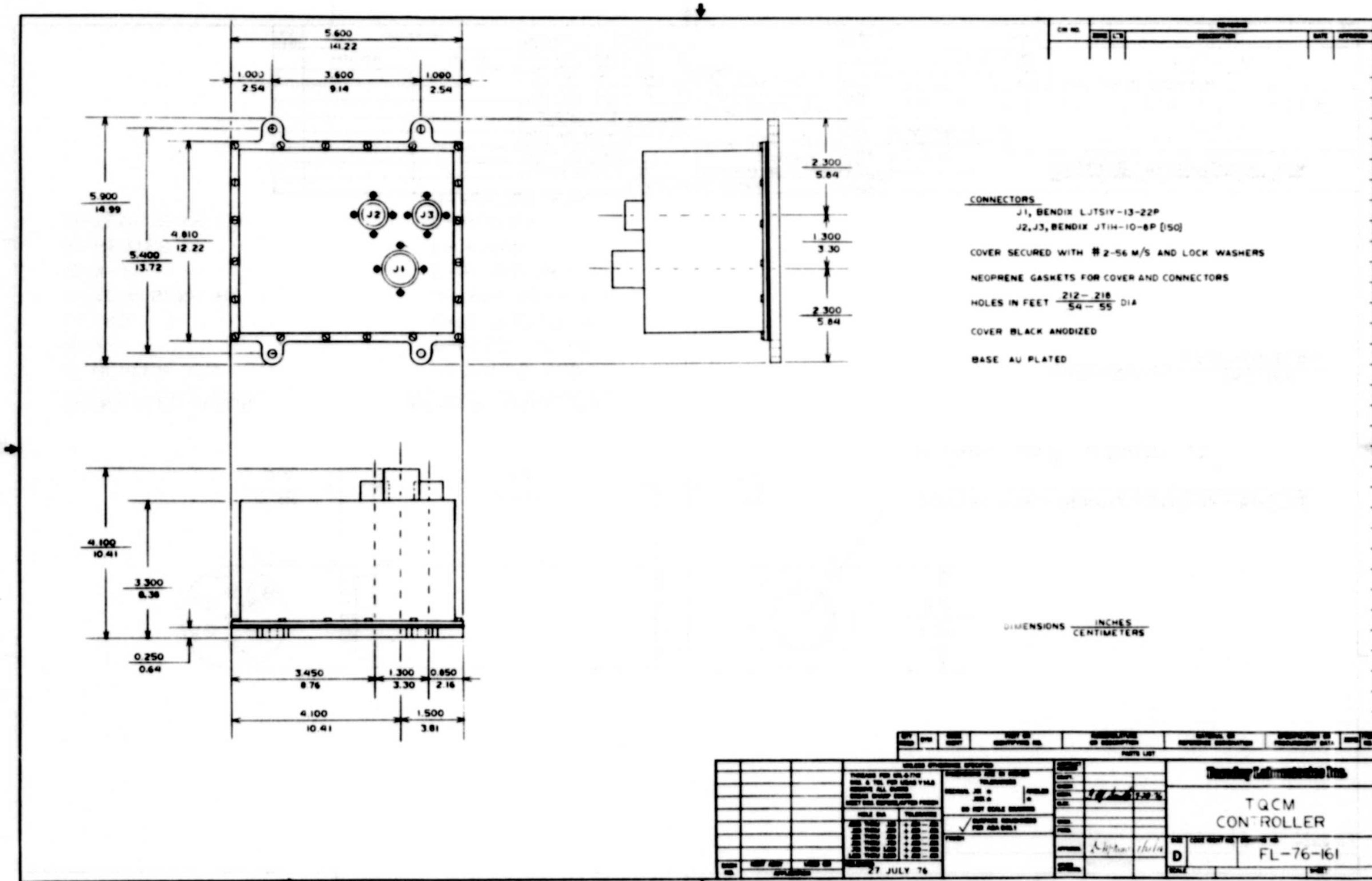

5.600
141.22
1.000
2.54
3.600
9.14
1.000
2.54
5.900
14.99
5.400
13.72
4.810
12.22
J1
J2
J3
2.300
5.84
1.300
3.30
2.300
5.84
CONNECTORS
J1, BENDIX LJTSIY-13-22P
J2, J3, BENDIX JTIH-10-6P [150]
COVER SECURED WITH #2-56 M/S AND LOCK WASHERS
NEOPRENE GASKETS FOR COVER AND CONNECTORS
HOLES IN FEET 212-218 / 54-55 DIA
COVER BLACK ANODIZED
BASE AU PLATED
4.100
10.41
3.300
8.38
0.250
0.64
3.450
8.76
1.300
3.30
0.850
2.16
4.100
10.41
1.500
3.81
DIMENSIONS INCHES / CENTIMETERS
TQCM
CONTROLLER
D
FL-76-161
27 JULY 76

Figure 50

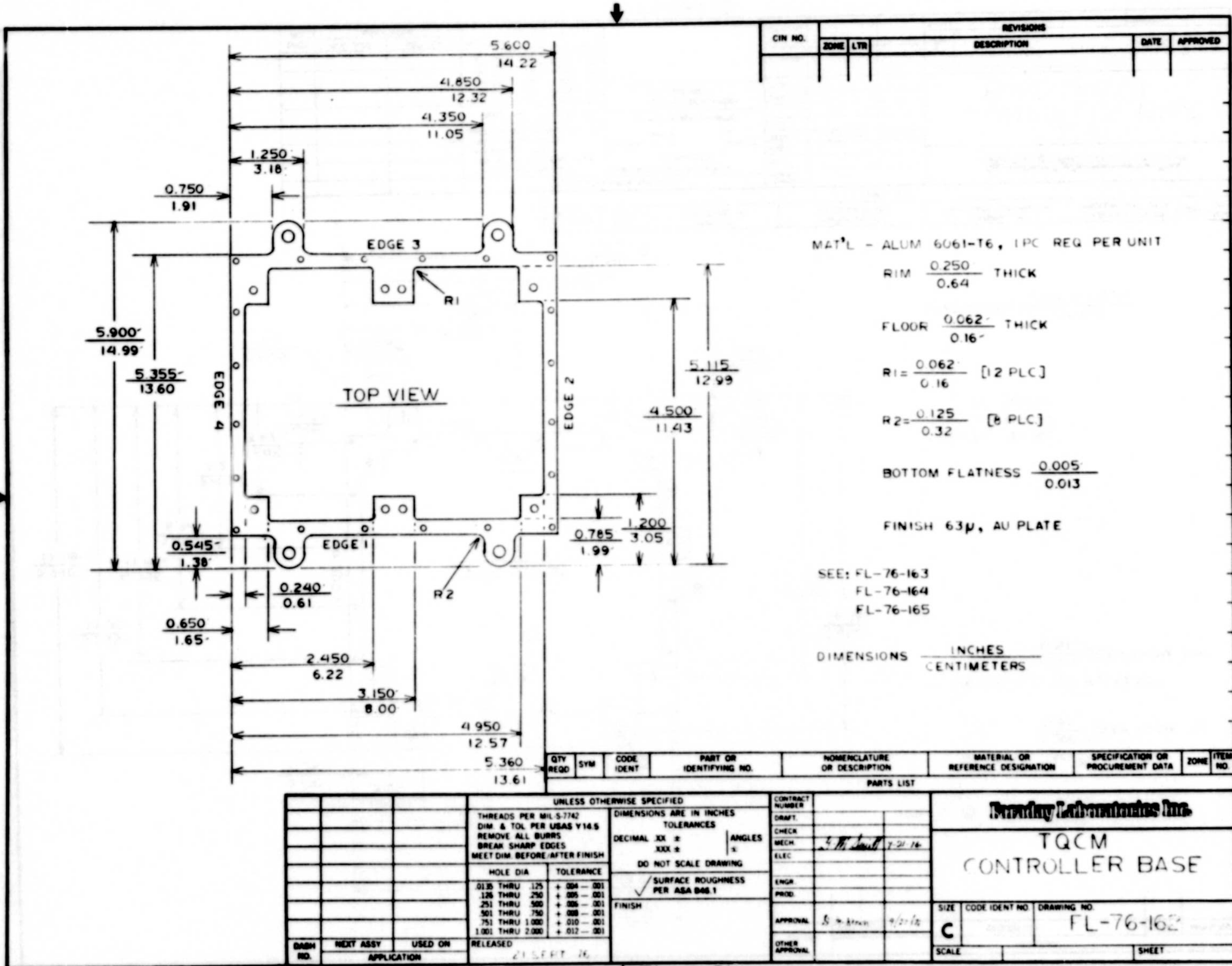

TOP VIEW
EDGE 1
EDGE 2
EDGE 3
EDGE 4
R1
R2
5.600 / 14.22
4.850 / 12.32
4.350 / 11.05
1.250 / 3.18
0.750 / 1.91
5.900 / 14.99
5.355 / 13.60
0.545 / 1.38
0.240 / 0.61
0.650 / 1.65
2.450 / 6.22
3.150 / 8.00
4.950 / 12.57
5.360 / 13.61
5.115 / 12.99
4.500 / 11.43
0.785 / 1.99
1.200 / 3.05
MAT'L - ALUM 6061-T6, 1PC REQ PER UNIT
RIM 0.250 / 0.64 THICK
FLOOR 0.062 / 0.16 THICK
R1 = 0.062 / 0.16 [12 PLC]
R2 = 0.125 / 0.32 [8 PLC]
BOTTOM FLATNESS 0.005 / 0.013
FINISH 63μ, AU PLATE
SEE: FL-76-163
FL-76-164
FL-76-165
DIMENSIONS INCHES / CENTIMETERS
REVISIONS
CIN NO.
ZONE
LTR
DESCRIPTION
DATE
APPROVED
QTY REQD
SYM
CODE IDENT
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR REFERENCE DESIGNATION
SPECIFICATION OR PROCUREMENT DATA
ZONE
ITEM NO.
PARTS LIST
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM BEFORE/AFTER FINISH
HOLE DIA
TOLERANCE
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL XX ±
XXX ±
ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
FINISH
RELEASED
21 SEPT 76
DASH NO.
NEXT ASSY
USED ON
APPLICATION
CONTRACT NUMBER
DRAFT
CHECK
MECH
ELEC
ENGR
PROD
APPROVAL
OTHER APPROVAL
Faraday Laboratories Inc.
TQCM
CONTROLLER BASE
SIZE
C
CODE IDENT NO.
DRAWING NO.
FL-76-162
SCALE
SHEET

Figure 51

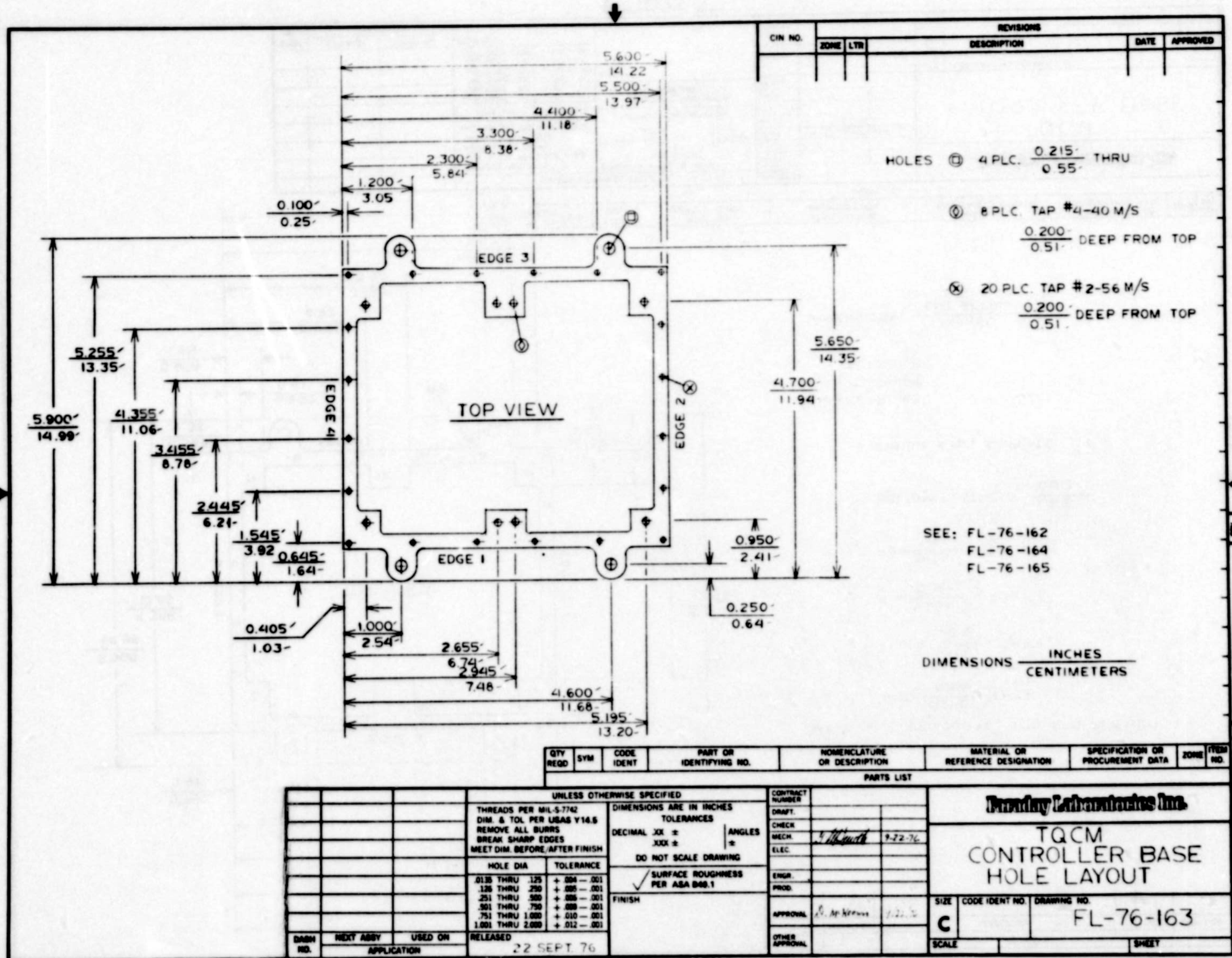
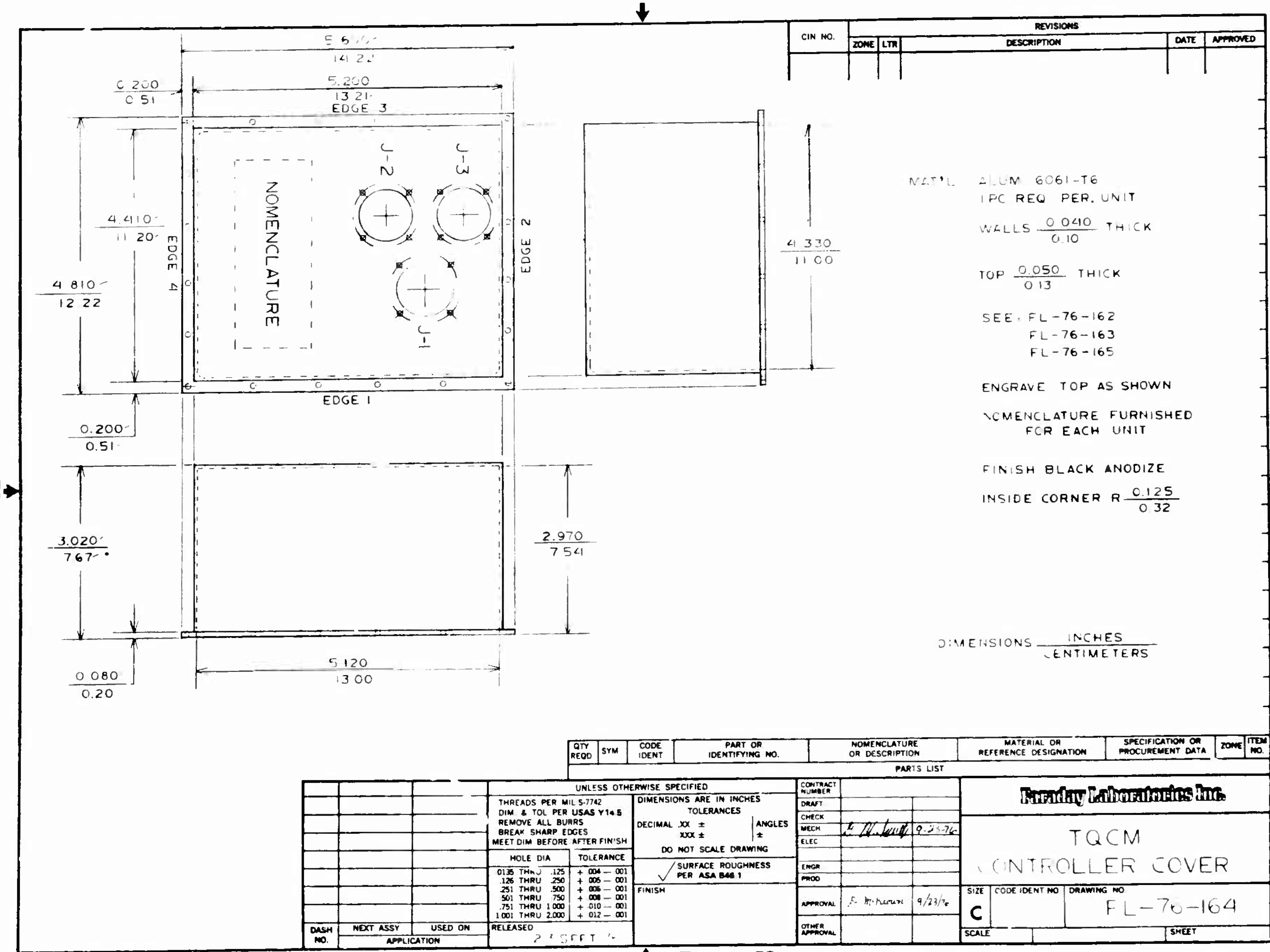

TOP VIEW
EDGE 1
EDGE 2
EDGE 3
EDGE 4
HOLES 4 PLC. 0.215 / 0.55 THRU
8 PLC. TAP #4-40 M/S 0.200 / 0.51 DEEP FROM TOP
20 PLC. TAP #2-56 M/S 0.200 / 0.51 DEEP FROM TOP
SEE: FL-76-162
FL-76-164
FL-76-165
DIMENSIONS INCHES / CENTIMETERS
5.600 / 14.22
5.500 / 13.97
4.400 / 11.18
3.300 / 8.38
2.300 / 5.84
1.200 / 3.05
0.100 / 0.25
5.900 / 14.99
5.255 / 13.35
4.1355 / 11.06
3.4155 / 8.78
2.445 / 6.21
1.545 / 3.92
0.645 / 1.64
0.405 / 1.03
1.000 / 2.54
2.655 / 6.74
2.945 / 7.48
4.600 / 11.68
5.195 / 13.20
5.650 / 14.35
4.700 / 11.94
0.950 / 2.41
0.250 / 0.64
REVISIONS
CIN NO.
ZONE
LTR
DESCRIPTION
DATE
APPROVED
QTY REQD
SYM
CODE IDENT
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR REFERENCE DESIGNATION
SPECIFICATION OR PROCUREMENT DATA
ZONE
ITEM NO.
PARTS LIST
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM. BEFORE/AFTER FINISH
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL .XX ±
.XXX ±
ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
HOLE DIA
TOLERANCE
.0135 THRU .125 + .004 — .001
.126 THRU .250 + .005 — .001
.251 THRU .500 + .006 — .001
.501 THRU .750 + .008 — .001
.751 THRU 1.000 + .010 — .001
1.001 THRU 2.000 + .012 — .001
FINISH
DASH NO.
NEXT ASSY
USED ON
APPLICATION
RELEASED
22 SEPT. 76
CONTRACT NUMBER
DRAFT.
CHECK
MECH.
ELEC.
ENGR.
PROD.
APPROVAL
OTHER APPROVAL
9-22-76
Faraday Laboratories Inc.
TQCM
CONTROLLER BASE
HOLE LAYOUT
SIZE
C
CODE IDENT NO.
DRAWING NO.
FL-76-163
SCALE
SHEET

Figure 52



5.600 / 14.22
5.200 / 13.21
0.200 / 0.51
EDGE 3
EDGE 1
EDGE 2
EDGE 4
NOMENCLATURE
J-1
J-2
J-3
4.410 / 11.20
4.810 / 12.22
0.200 / 0.51
3.020 / 7.67
2.970 / 7.54
0.080 / 0.20
5.120 / 13.00
4.330 / 11.00
MAT'L ALUM 6061-T6
1 PC REQ PER. UNIT
WALLS 0.040 / 0.10 THICK
TOP 0.050 / 0.13 THICK
SEE: FL-76-162
FL-76-163
FL-76-165
ENGRAVE TOP AS SHOWN
NOMENCLATURE FURNISHED FOR EACH UNIT
FINISH BLACK ANODIZE
INSIDE CORNER R 0.125 / 0.32
DIMENSIONS INCHES / CENTIMETERS
CIN NO.
REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
QTY REQD
SYM
CODE IDENT
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR REFERENCE DESIGNATION
SPECIFICATION OR PROCUREMENT DATA
ZONE
ITEM NO.
PARTS LIST
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL S-7742
DIM & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM BEFORE AFTER FINISH
HOLE DIA
TOLERANCE
.0135 THRU .125 + .004 — .001
.126 THRU .250 + .005 — .001
.251 THRU .500 + .006 — .001
.501 THRU .750 + .008 — .001
.751 THRU 1.000 + .010 — .001
1.001 THRU 2.000 + .012 — .001
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL .XX ±
.XXX ±
ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
FINISH
CONTRACT NUMBER
DRAFT
CHECK
MECH
ELEC
ENGR
PROD
APPROVAL
OTHER APPROVAL
9-23-76
9/23/76
DASH NO.
NEXT ASSY
USED ON
APPLICATION
RELEASED
Faraday Laboratories Inc.
TQCM
CONTROLLER COVER
SIZE
C
CODE IDENT NO
DRAWING NO
FL-76-164
SCALE
SHEET

Figure 53

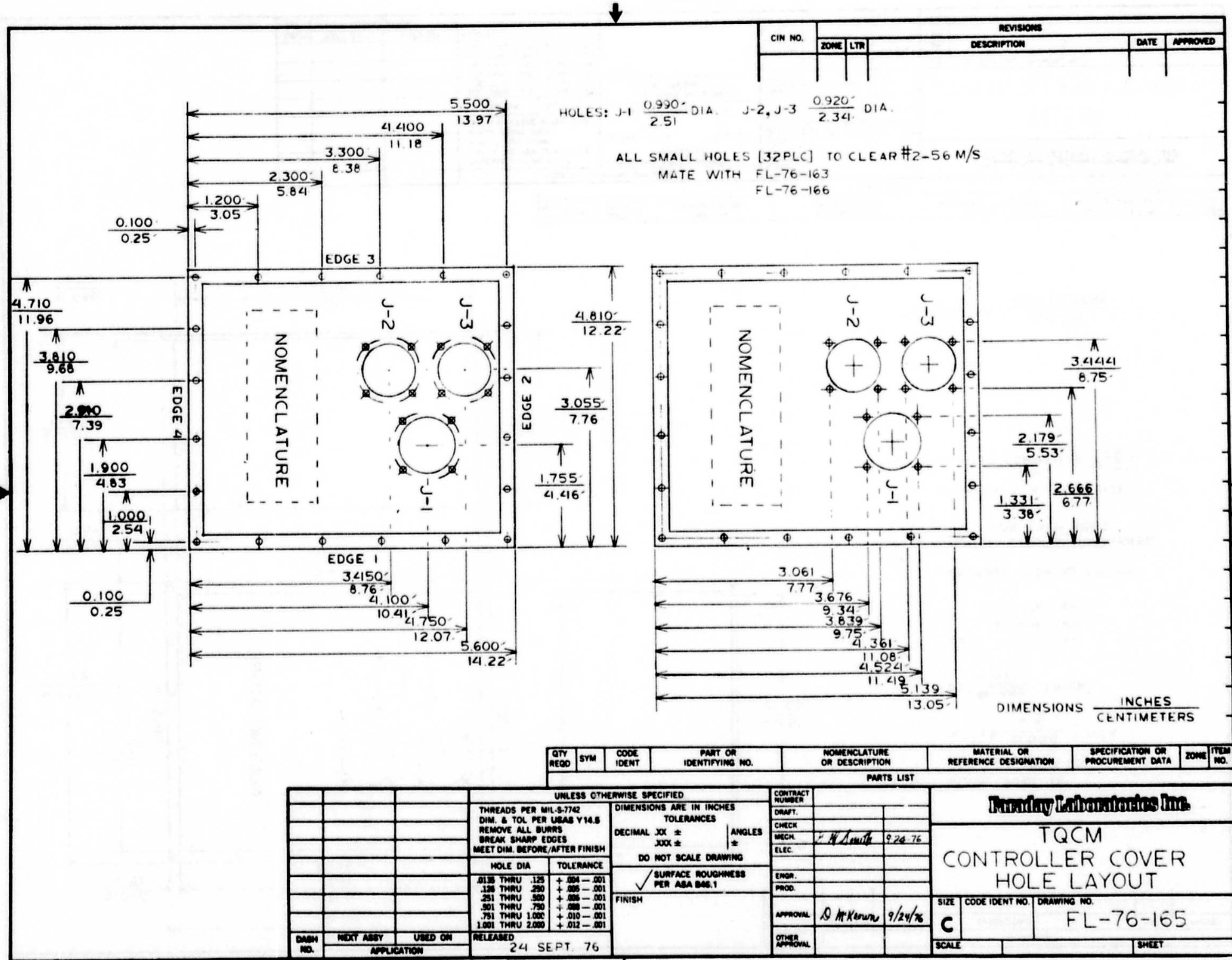
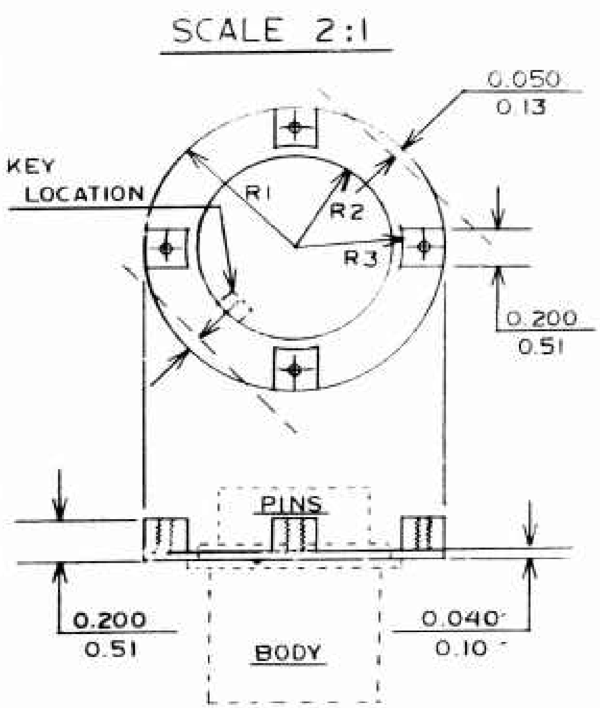

HOLES: J-1 0.990″/2.51 DIA. J-2, J-3 0.920″/2.34 DIA.
ALL SMALL HOLES [32PLC] TO CLEAR #2-56 M/S
MATE WITH FL-76-163
FL-76-166
EDGE 1
EDGE 2
EDGE 3
EDGE 4
NOMENCLATURE
J-1
J-2
J-3
DIMENSIONS INCHES/CENTIMETERS
Faraday Laboratories Inc.
TQCM
CONTROLLER COVER
HOLE LAYOUT
FL-76-165
RELEASED 24 SEPT. 76
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
DO NOT SCALE DRAWING
PARTS LIST
REVISIONS

Figure 54



J-1 MNTNG RING 1 PC REQ

CONNECTOR = BENDIX LJTS1Y-13-22P

R1 $\frac{0.700}{1.78}$ R2 $\frac{0.453}{1.15}$ R3 $\frac{0.500}{1.27}$ BC $\frac{1.200}{3.05}$

J-2, J-3 MNTNG RINGS 2 PC REQ

CONNECTOR = BENDIX JTIH-12-8P [150]

R1 $\frac{0.650}{1.65}$ R2 $\frac{0.393}{1.00}$ R3 $\frac{0.450}{1.14}$ BC $\frac{1.100}{2.79}$

REMOVE $\frac{0.050}{0.13}$ FROM O.D. IN 2 PLC AS SHOWN ON J-2 AND J-3 RINGS

HOLES 4 PLC #2-56 M/S X $\frac{0.130}{0.33}$ DEEP TAPPED FROM FLAT SIDE

SOLDER CONNECTORS TO RINGS INDEX KEY AS SHOWN

MAT'L -304 ST. ST. RINGS MATE WITH FL-76-165

DIMENSIONS $\frac{\text{INCHES}}{\text{CENTIMETERS}}$

CONNECTOR MOUNTING RINGS

REVISIONS: ZONE | LTR | DESCRIPTION | DATE | APPROVED

UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM BEFORE/AFTER FINISH

HOLE DIA	TOLERANCE
.0135 THRU .125	+ .004 — .001
.126 THRU .250	+ .005 — .001
.251 THRU .500	+ .006 — .001
.501 THRU .750	+ .008 — .001
.751 THRU 1.000	+ .010 — .001
1.001 THRU 2.000	+ .012 — .001

DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL .XX ± .XXX ± | ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS ✓ PER ASA B46.1
FINISH

NEXT ASSY | USED ON
DASH NO. | APPLICATION
RELEASED 29 SEPT 76

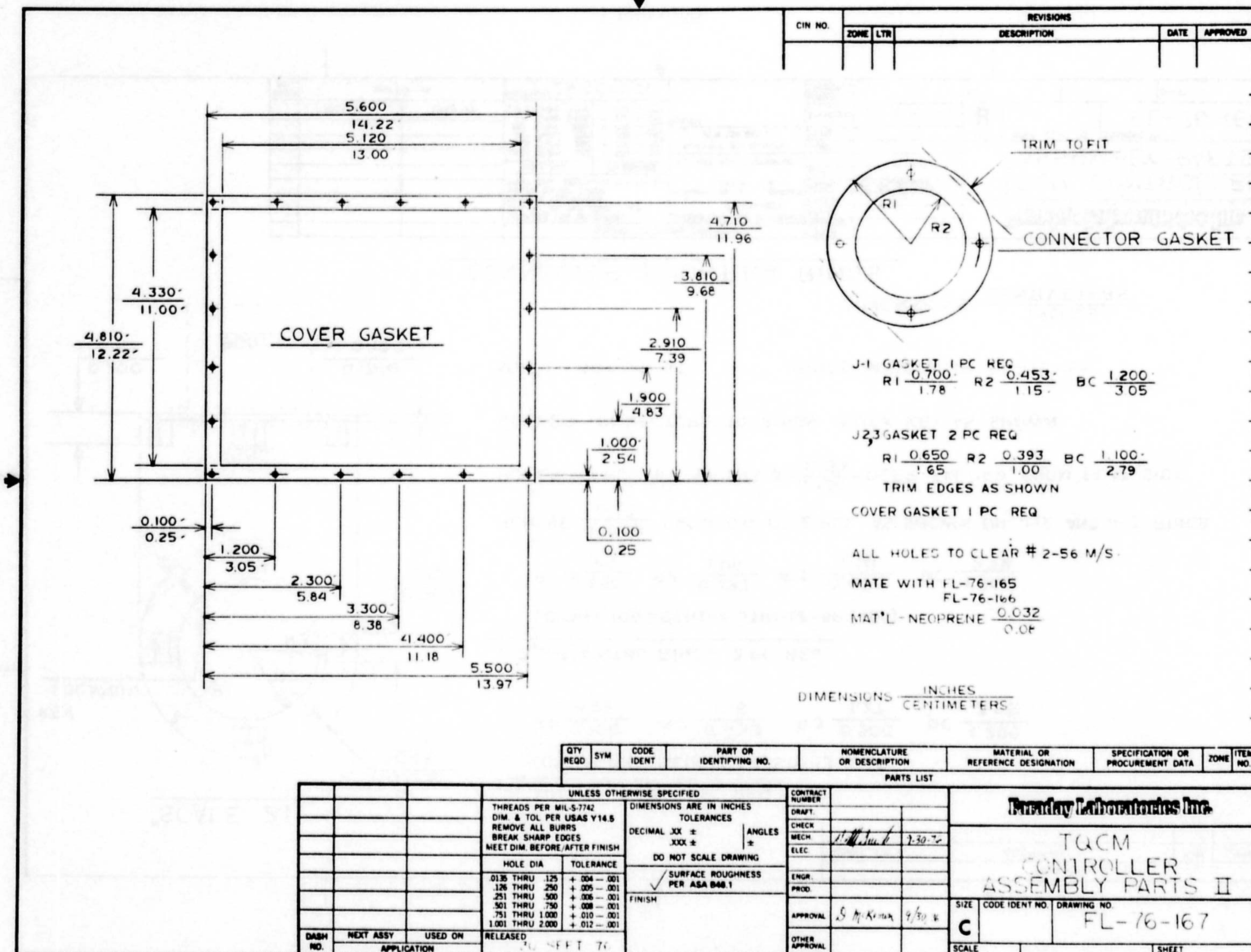
CONTR NUMBER
DRAFT.
CHECK
MECH
ELEC
ENGR.
PROD
APPROVAL
OTHER APPROVAL

Faraday Laboratories Inc.

TQCM CONTROLLER ASSEMBLY PARTS I

SIZE B | CODE IDENT NO. | DRAWING NO. FL-76-166
SCALE | SHEET

Figure 55



COVER GASKET
5.600 / 14.22
5.120 / 13.00
4.330 / 11.00
4.810 / 12.22
0.100 / 0.25
1.200 / 3.05
2.300 / 5.84
3.300 / 8.38
41.400 / 11.18
5.500 / 13.97
4.710 / 11.96
3.810 / 9.68
2.910 / 7.39
1.900 / 4.83
1.000 / 2.54
0.100 / 0.25
TRIM TO FIT
R1
R2
CONNECTOR GASKET
J-1 GASKET 1 PC REQ
R1 0.700 / 1.78 R2 0.453 / 1.15 BC 1.200 / 3.05
J2,3 GASKET 2 PC REQ
R1 0.650 / 1.65 R2 0.393 / 1.00 BC 1.100 / 2.79
TRIM EDGES AS SHOWN
COVER GASKET 1 PC REQ
ALL HOLES TO CLEAR # 2-56 M/S
MATE WITH FL-76-165
FL-76-166
MAT'L-NEOPRENE 0.032 / 0.08
DIMENSIONS INCHES / CENTIMETERS
CIN NO.
REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
QTY REQD
SYM
CODE IDENT
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR REFERENCE DESIGNATION
SPECIFICATION OR PROCUREMENT DATA
ZONE
ITEM NO.
PARTS LIST
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM. BEFORE/AFTER FINISH
HOLE DIA
TOLERANCE
.0135 THRU .125 + .004 — .001
.126 THRU .250 + .005 — .001
.251 THRU .500 + .006 — .001
.501 THRU .750 + .008 — .001
.751 THRU 1.000 + .010 — .001
1.001 THRU 2.000 + .012 — .001
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL .XX ±
.XXX ±
ANGLES
±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
FINISH
DASH NO.
NEXT ASSY
USED ON
APPLICATION
RELEASED
CONTRACT NUMBER
DRAFT.
CHECK
MECH.
ELEC.
ENGR.
PROD.
APPROVAL
OTHER APPROVAL
Faraday Laboratories Inc.
TQCM
CONTROLLER
ASSEMBLY PARTS II
SIZE
C
CODE IDENT NO.
DRAWING NO.
FL-76-167
SCALE
SHEET

Figure 56

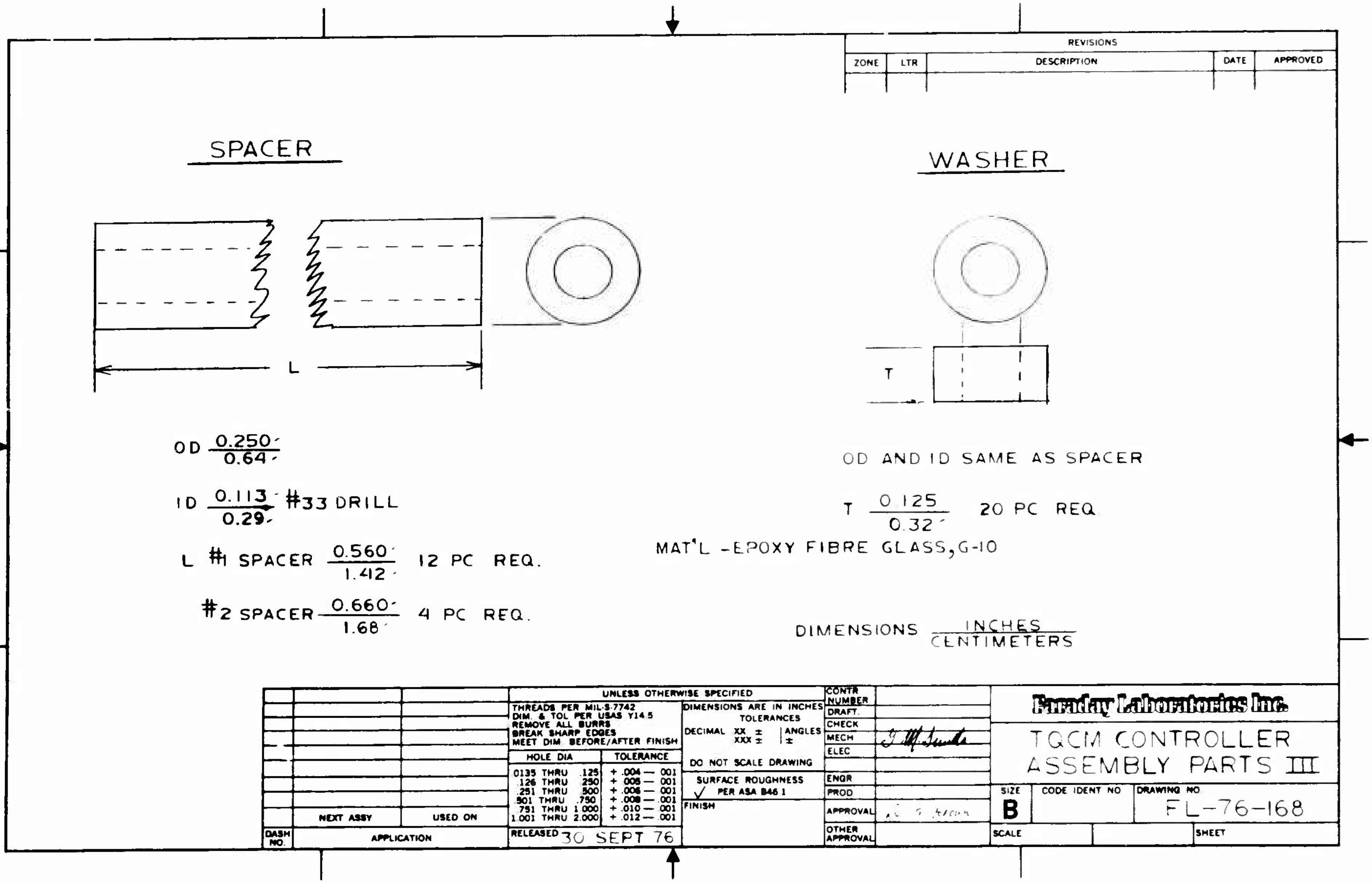
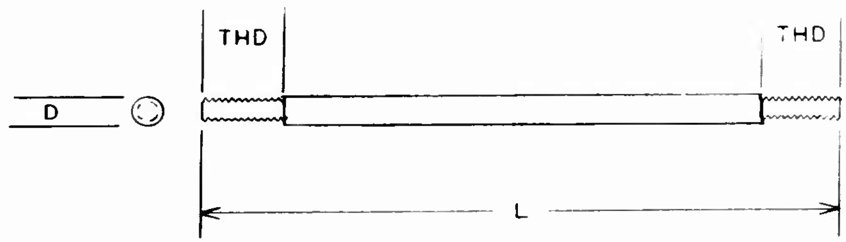

REVISIONS
ZONE
LTR
DESCRIPTION
DATE
APPROVED
SPACER
L
OD 0.250" / 0.64
ID 0.113" / 0.29 #33 DRILL
L #1 SPACER 0.560" / 1.412 12 PC REQ.
#2 SPACER 0.660" / 1.68 4 PC REQ.
WASHER
T
OD AND ID SAME AS SPACER
T 0.125 / 0.32 20 PC REQ
MAT'L -EPOXY FIBRE GLASS, G-10
DIMENSIONS INCHES / CENTIMETERS
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM BEFORE/AFTER FINISH
HOLE DIA
TOLERANCE
0135 THRU .125 + .004 — .001
.126 THRU .250 + .005 — .001
.251 THRU .500 + .006 — .001
.501 THRU .750 + .008 — .001
.751 THRU 1.000 + .010 — .001
1.001 THRU 2.000 + .012 — .001
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL XX ± XXX ± ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
FINISH
RELEASED 30 SEPT 76
NEXT ASSY
USED ON
APPLICATION
DASH NO.
CONTR NUMBER
DRAFT.
CHECK
MECH
ELEC
ENGR
PROD
APPROVAL
OTHER APPROVAL
Faraday Laboratories Inc.
TQCM CONTROLLER
ASSEMBLY PARTS III
SIZE B
CODE IDENT NO
DRAWING NO FL-76-168
SCALE
SHEET

Figure 57

MODULE ASSEMBLY ROD



D $\frac{0.112}{0.28}$

L #1 ROD $\frac{2.700}{6.86}$ 4 PC REQ

#2 ROD $\frac{2.300}{5.84}$ 4 PC REQ

THD #2-56 M/S x $\frac{0.300}{0.76}$ L BOTH ENDS

MAT'L 304 ST ST.

DIMENSIONS $\frac{\text{INCHES}}{\text{CENTIMETERS}}$

REVISIONS

ZONE	LTR	DESCRIPTION	DATE	APPROVED

UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM. & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM. BEFORE/AFTER FINISH

HOLE DIA	TOLERANCE
.0135 THRU .125	+ .004 — .001
.126 THRU .250	+ .005 — .001
.251 THRU .500	+ .006 — .001
.501 THRU .750	+ .008 — .001
.751 THRU 1.000	+ .010 — .001
1.001 THRU 2.000	+ .012 — .001

DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL XX ± XXX ± | ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS ✓ PER ASA B46.1
FINISH

RELEASED 30 SEPT 76

CONTR NUMBER
DRAFT
CHECK
MECH
ELEC
ENGR
PROD
APPROVAL
OTHER APPROVAL

NEXT ASSY | USED ON
DASH NO. | APPLICATION

Faraday Laboratories Inc.

TQCM CONTROLLER ASSEMBLY PARTS IV

SIZE B | CODE IDENT NO | DRAWING NO FL-76-169

SCALE | SHEET

Figure 58

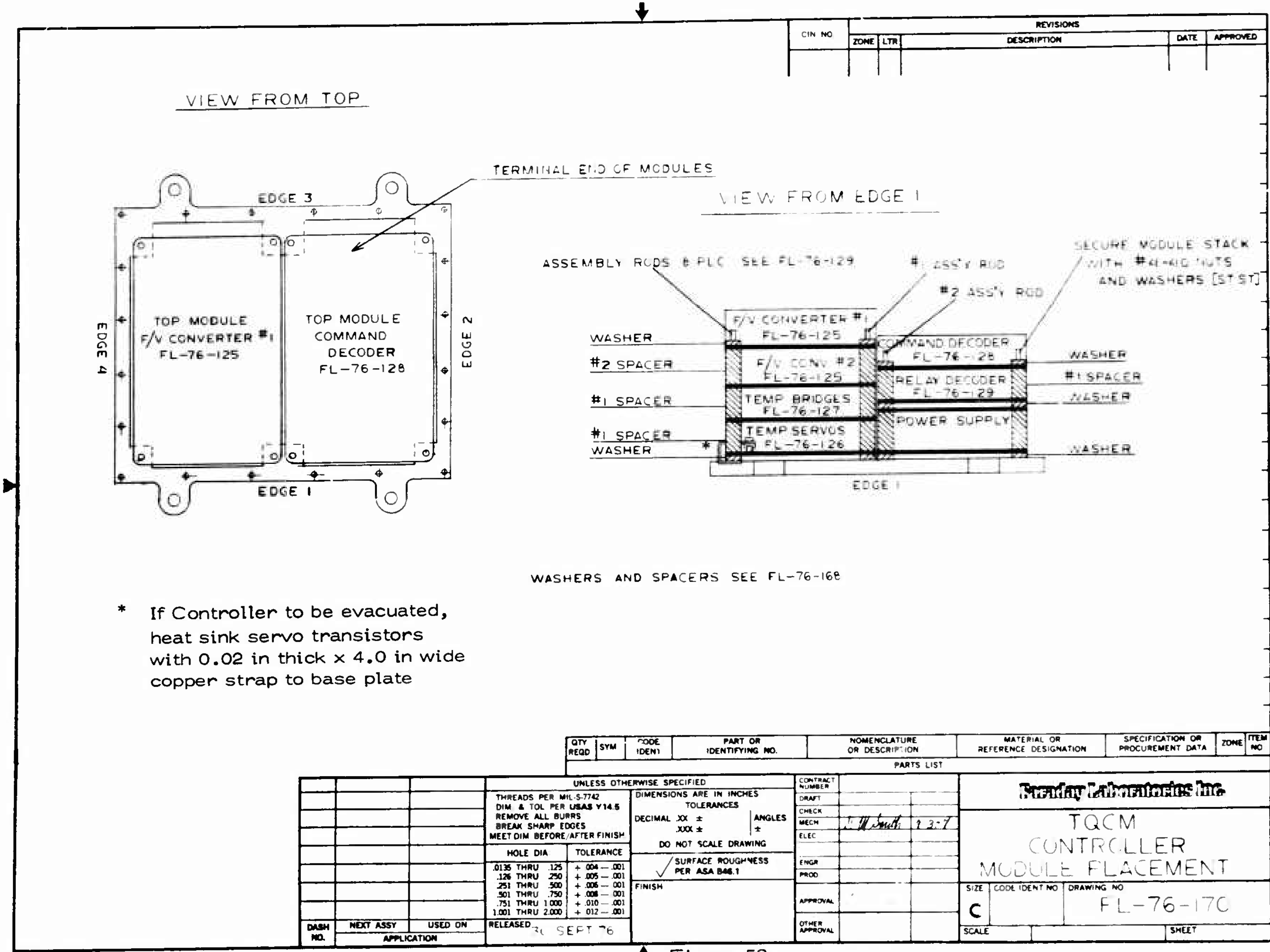

VIEW FROM TOP
TERMINAL END OF MODULES
EDGE 3
EDGE 4
EDGE 2
EDGE 1
TOP MODULE F/V CONVERTER #1 FL-76-125
TOP MODULE COMMAND DECODER FL-76-128
VIEW FROM EDGE 1
ASSEMBLY RODS 6 PLC SEE FL-76-129
#1 ASS'Y ROD
#2 ASS'Y ROD
SECURE MODULE STACK WITH #4-40 NUTS AND WASHERS [ST ST]
WASHER
#2 SPACER
#1 SPACER
#1 SPACER
WASHER
F/V CONVERTER #1 FL-76-125
F/V CONV #2 FL-76-125
TEMP BRIDGES FL-76-127
TEMP SERVOS FL-76-126
COMMAND DECODER FL-76-128
RELAY DECODER FL-76-129
POWER SUPPLY
WASHER
#1 SPACER
WASHER
WASHER
EDGE 1
WASHERS AND SPACERS SEE FL-76-168
* If Controller to be evacuated, heat sink servo transistors with 0.02 in thick x 4.0 in wide copper strap to base plate
REVISIONS
CIN NO
ZONE
LTR
DESCRIPTION
DATE
APPROVED
QTY REQD
SYM
CODE IDENT
PART OR IDENTIFYING NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL OR REFERENCE DESIGNATION
SPECIFICATION OR PROCUREMENT DATA
ZONE
ITEM NO
PARTS LIST
UNLESS OTHERWISE SPECIFIED
THREADS PER MIL-S-7742
DIM & TOL PER USAS Y14.5
REMOVE ALL BURRS
BREAK SHARP EDGES
MEET DIM BEFORE/AFTER FINISH
HOLE DIA
TOLERANCE
.0135 THRU .125 + .004 — .001
.126 THRU .250 + .005 — .001
.251 THRU .500 + .006 — .001
.501 THRU .750 + .008 — .001
.751 THRU 1.000 + .010 — .001
1.001 THRU 2.000 + .012 — .001
DIMENSIONS ARE IN INCHES
TOLERANCES
DECIMAL .XX ±
.XXX ±
ANGLES ±
DO NOT SCALE DRAWING
SURFACE ROUGHNESS PER ASA B46.1
FINISH
CONTRACT NUMBER
DRAFT
CHECK
MECH
ELEC
ENGR
PROD
APPROVAL
OTHER APPROVAL
DASH NO.
NEXT ASSY
USED ON
APPLICATION
RELEASED
SEPT 76
TQCM
CONTROLLER
MODULE PLACEMENT
SIZE
C
CODE IDENT NO
DRAWING NO
FL-76-170
SCALE
SHEET

Figure 59

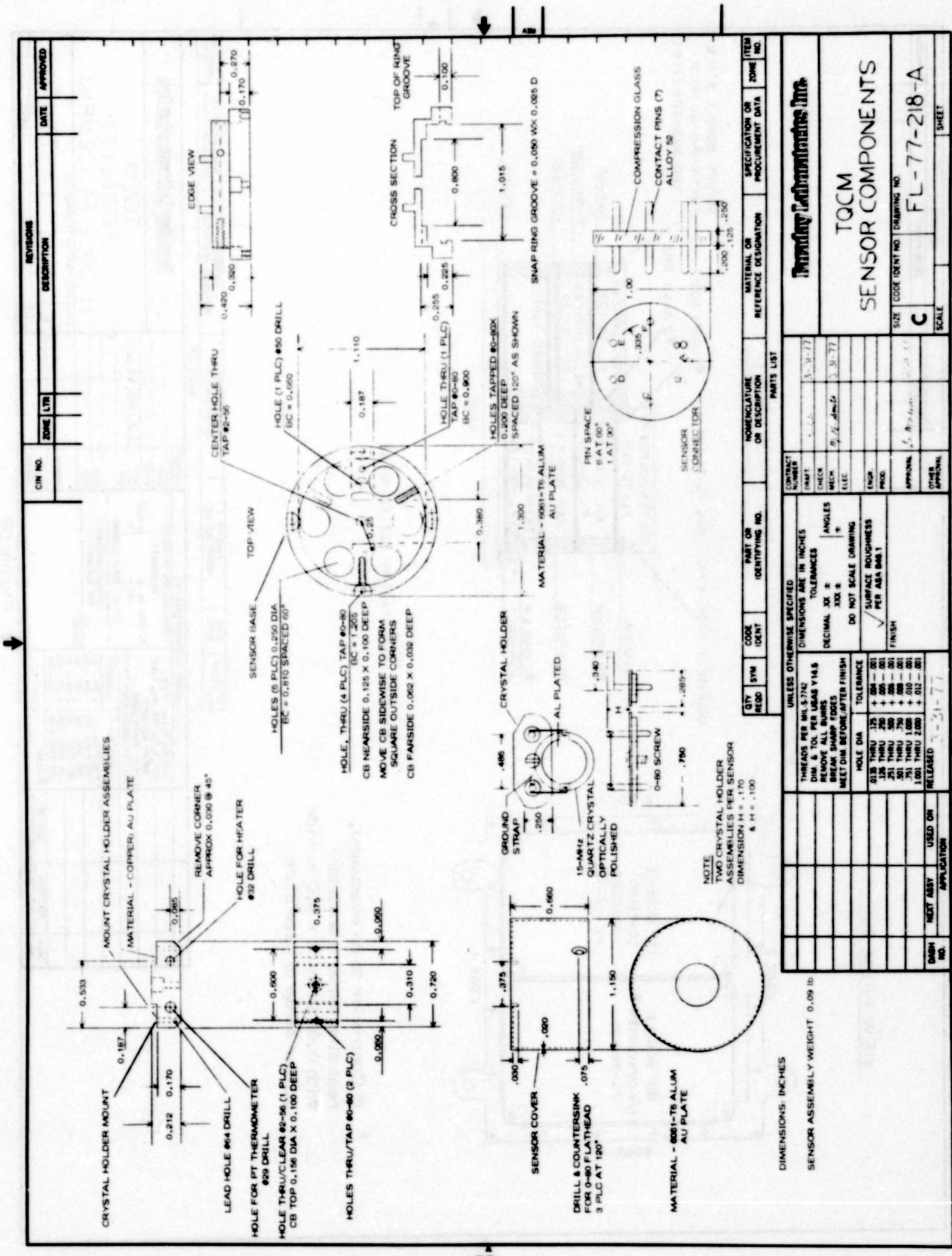


Figure 60

☆U.S.Government Printing Office: 1977 — 757-080/181

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